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THE BACTERIOLOGY OF COMMERCIALLY PASTEURIZED AND RAW MARKET MILK.

BY

S. HENRY AYERS,
Bacteriologist, Dairy Division,
AND
WILLIAM T. JOHNSON, JR.,
Scientific Assistant, Dairy Division.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., July 8, 1910.

Sir: I have the honor to transmit herewith, and to recommend for publication as a bulletin of this Bureau, a manuscript entitled "The Bacteriology of Commercially Pasteurized and Raw Market Milk," by S. Henry Ayers, bacteriologist, and William T. Johnson, Jr., scientific assistant, in the Dairy Division of this Bureau.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 7
Modern theories of pasteurization 7
    Advantages claimed for the process 7
    Objections to pasteurization 10
Object of this investigation 14
Methods 14
Pasteurization experiments 14
    Comparison of raw milk and milk pasteurized by the "flash" process 15
        Experiment with milk held at 10° C. (50° F.) 15
        The increase in peptonizing bacteria 18
        Experiments with milk held at room temperature 19
        The increase in acidity 20
    Comparison of raw milk and milk pasteurized by the "holder" process 21
        Reduction of bacteria during the holding process 21
Examination of pasteurized and raw milk under commercial conditions 22
    The pasteurized milk supply of a small city 23
    A study of pasteurized and raw milk in Boston 25
        Winter milk 27
        Summer milk 29
    A study of pasteurized and raw milk in New York City 32
        The differential bacteriological content 33
        Development of acidity 36
        Growth of peptonizing bacteria 37
    Raw milk in Washington, D. C 39
Discussion of results obtained from analysis of commercial milk 41
    A comparison of various grades of pasteurized and raw milk 41
    The absence of acid bacteria in best grades of raw milk 43
    The bacterial content of pasteurized and raw milk 45
        Initial counts of bacteria 45
        Rate of increase of the bacteria 46
        Inaccuracy of ratios of increase when initial counts vary too widely 50
Lactic-acid bacteria of high thermal death point 52
    Experiments to determine thermal death point 53
    Percentage of lactic-acid bacteria capable of withstanding high temperatures 56
Summary and conclusions 58
    Conclusions 58
Acknowledgments 61
References to literature 62
Appendix—Tables I to XVIII 64

ILLUSTRATIONS.

Page.

FIG. 1. Pasteurization experiments. Comparison of acidities of raw and pasteurized milk.......... 20
2. Pasteurized milk in a small city. Average daily counts of bacteria and average daily acidity.......... 24
3. Winter milk at Boston, Mass. Average daily counts of bacteria and average daily acidity of raw and pasteurized milk.......... 26
4. Winter milk at Boston, Mass. Average daily counts of bacteria and average daily acidity of pasteurized milk at room temperature.......... 29
5. Summer milk at Boston, Mass. Average daily counts of bacteria and average daily acidity of raw and pasteurized milk.......... 30
6. Pasteurized milk in New York City, "holder" process. Average daily counts of bacteria and average daily acidity.......... 33
7. Pasteurized milk in New York City, "flash" process. Average daily counts of bacteria and average daily acidity.......... 34
8. Raw milk in New York City. Average daily counts of bacteria and average daily acidity.......... 35
9. Raw and pasteurized milk at New York City. Average daily counts of bacteria and average daily acidity of milk at room temperature.......... 36
10. Raw and pasteurized milk in New York City. Comparison of average daily acidity.......... 37
11. Raw milk at Washington, D. C. Average daily counts of bacteria and average daily acidity at 10° C. (50° F.).......... 40
12. Raw milk at Washington, D. C. Average daily counts of bacteria and average daily acidity at room temperature.......... 41
13. Comparison of high-grade raw and pasteurized milk held at 10° C. (50° F.). Average daily counts and group percentages of bacteria.......... 41
14. Comparison of high-grade raw and pasteurized milk held at room temperature. Average daily counts of bacteria.......... 42
15. Comparison of high and low grade pasteurized milk with raw milk. Average daily counts of bacteria.......... 43
16. Comparison of the ratio of increase of bacteria in pasteurized and raw milk.......... 50

THE BACTERIOLOGY OF COMMERCIALLY PASTEURIZED AND RAW MARKET MILK.

INTRODUCTION.

Pasteurization is a term which needs no explanation, nor is it necessary to review its history. The general public has been liberally informed during the past two years as to what the pasteurization of milk means. It is true that newspaper articles often are misleading, and the minds of the people have been led to favor or oppose pasteurization largely through popular articles in the press or advertisements of dairies, which either point out the value of or the danger from pasteurized milk.

But the question as to pasteurization is not unsettled in the public mind alone; the subject is one which has caused a division of opinion also in the medical profession and in the scientific world. There are those who oppose pasteurization and those who are in favor of it. Some oppose it under any condition; others admit that it should be resorted to under exceptional conditions.

It may be asked with fairness why such a division of opinion exists among even those who have made milk problems a life study. Only one answer can be given, namely, that the subject of pasteurization has as yet been touched only upon the surface, notwithstanding the numerous valuable pieces of research work which have been published concerning it.

MODERN THEORIES OF PASTEURIZATION.

Since the pasteurization of milk has become extensively practiced and is advocated by health officers and other authorities on milk, obviously there must be some advantages connected with the process. Some of the points of value in pasteurization which serve as a foundation for the opinions of those who advocate the process may be considered first.

ADVANTAGES CLAIMED FOR THE PROCESS.

When the rôle that raw milk plays as a vehicle of disease and the ease with which it may become infected are considered, obviously the principal advantage of pasteurization is in the destruction of pathogenic organisms. It has been shown by many investigators that *Bacillus tuberculosis, B. typhi, B. diphtheriæ,* and the dysentery bacillus are destroyed when milk is pasteurized at 60° C. (140° F.) for twenty minutes. While epidemics caused by infected milk may occur only at rare intervals, any possible means of protection seems justifiable. Sanitary inspection has greatly improved the milk supply, but under present conditions its scope is limited by the magnitude of the problem. The aim of sanitary supervision is to improve the conditions under which milk is produced. The goal of the struggle for improved milk is the production of clean milk from tuberculin-tested herds, preferably produced by a few large dairy farms which are under the supervision of competent men, rather than on a large number of small farms. Granting, however, that ideal conditions can be ultimately reached, we are nevertheless confronted by entirely different conditions at the present time. Certified milk is produced in relatively small amounts in this country, and its cost of production makes its price prohibitive for a large majority of people. A good grade of clean milk may be furnished to a city where the consumption of milk is small enough to allow constant inspection of the dairy farms supplying the city. With large cities the problem is different. For example, take the case of New York, where the milk supply comes from approximately 35,000 farms located in 6 different States and is shipped from about 700 dairies. With milk coming from such a large area, constant sanitary supervision is an immense problem. In such a case the general conditions on the farms may be improved, but to expect in the immediate future to have all the milk come from tuberculin-tested cows and to have inspection of the farms efficient enough to prevent the possibility of typhoid infection is beyond reason.

The frequency of tubercle bacilli in market milk is well known. Anderson[3][a] in an examination of market milk in Washington, D. C., has shown that milk from approximately 11 per cent of the dairies examined contained tubercle bacilli virulent for guinea pigs. Examinations even of certified milk sometimes show the presence of the tubercle bacillus.

The number of epidemics of typhoid fever traced to milk is striking. Schüder[23] collected from the literature statistics of 650 typhoid epidemics, the supposed cause of which had been reported. Of these 462 were reported as spread by water, 110 by milk, and 78 by other agents. Lumsden[13] gives figures showing the theoretical number of typhoid cases in Washington during one year which may be expected to be caused by infected milk. According to his figures 1,000 farms supply Washington, and by estimating seven persons living at each farm and considering that in the United States every year about 1 in every 300 persons has typhoid fever, then some 25 cases per year may be expected to occur on dairy farms supplying the city.

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[a] The figures refer to the list of references on pages 62 and 63.

It is easy to see how typhoid on farms may be readily conveyed by means of milk to the city, where epidemics may result. Even with sanitary supervision of the farms it is hard and practically impossible to prevent occasional infection of the milk. Frequently cases of typhoid fever are not recognized up to the second or third week of illness, until which time no precautions are taken. In many instances mild cases are unattended by a physician and even in some cases may not be recognized. Persons who have recovered from the disease but who are still discharging typhoid bacilli in their stools and urine may directly infect the milk while handling it.

The rôle of typhoid carriers in the spread of the disease in relation to the infection of milk is attracting attention. Albert[1] has shown that about 75 per cent of all carriers are women, and that, almost without exception, the carriers have been employed in some occupation, as baker, cook, or handler of milk, which has enabled them to transmit typhoid bacilli to substances used as food by others. He says that in some cases carriers had typhoid but a short time previous, and in other cases as long as ten, thirty, and even fifty-two years. He estimates that 1 in every 500 adults is a chronic carrier, while it has been estimated that there are about one-half as many carriers in a community as there are cases of typhoid fever. It is evident that to guard against chances of typhoid infection from an inspected dairy it may be necessary to have a medical examination of the dairymen.

Numerous cases of epidemics of diphtheria and scarlet fever, as well as more obscure diseases, have been traced to milk. In this connection Freeman[6] states:

> Diphtheria has apparently been spread by the best of our milk supplies. What protection have we against this in any raw milk? Virulent diphtheria bacilli exist in the throats of many healthy persons, and, though in our best dairies we have some medical supervision, no supervision could be practically enforced that would protect the milk from a beginning diphtheria or a healthy diphtheria bacillus carrier.

The numbers of bacteria in milk are of great importance in relation to intestinal diseases in children. The establishment of pasteurizing plants by Straus in various cities, where pasteurized milk is supplied to children of the poor, who are ordinarily compelled to use a dirty milk high in bacteria, as well as the use of commercially pasteurized milk, has done much to lower the infantile death rate. It seems to be the number of bacteria rather than the species which are concerned. Park[15] says:

> After five years of effort to discover some relation between special varieties of bacteria found in milk and the health of children the conclusion has been reached that neither through animal tests nor the isolation from the milk of sick infants have we been able to establish such a relation.

Kenwood[11] believes that the pasteurization of the public supply affords a readily available means of bringing about a reduction of infantile sickness, even if the maximum is conceded to those who discredit it. Lederle[12] in stating the advantages of pasteurized milk states:

> The great benefits derived from its use in infant feeding in hospitals, infant-milk depots, and in private practice will be attested by most physicians.

The destruction of a large percentage of the bacteria during pasteurization results in an improved keeping quality, which is of importance from a commercial as well as a hygienic point of view.

The principal advantages of pasteurization may be summarized as follows:

1. Protection from infection with the diseases usually transmitted by milk.
2. Reduction of bacteria and, as a consequence, of the infantile death rate.
3. The enhancing of the keeping quality of the milk.

It might seem that the advantages of pasteurization mentioned in the preceding pages were of sufficient value to advocate its general application. Many authorities, however, do not favor pasteurization. Some of the objections may be considered next.

OBJECTIONS TO PASTEURIZATION.

One of the most serious objections to pasteurized milk is that it is believed to putrefy rather than sour, due to the destruction of lactic-acid bacteria which produce acid in raw milk. The destruction of the acid bacteria is believed to result in the unhindered growth of undesirable organisms which may form toxins or other poisonous products, thus making the milk unfit for human consumption, especially in the case of young infants. This view dates back to the investigations of Flügge,[5] whose work on pasteurized milk heated to 70° C. (158° F.) for thirty minutes demonstrated the presence of spore-forming, peptonizing bacteria which developed in the milk and formed highly toxic substances. Weber,[24] however, found only three of these types of bacteria during an examination of 150 samples of commercial sterilized milk. Farrington and Russell[4] state that in numerous experiments they have found the thermal death point of the lactic-acid bacteria to be in the neighborhood of 57.2 to 60° C. (135 to 140° F.) where the exposure was for ten minutes. Russell and Hastings [21] state, in their book on Agricultural Bacteriology, that—

> The lactic bacteria do not form spores, and hence are easily killed if milk is heated. If milk is pasteurized and subsequently kept free from lactic bacteria, it will not sour, but will putrefy, due to the development of the spores not killed by the heating. Often the first sign of spoiling in pasteurized milk is the appearance of a bitter or other undesirable taste. Frequently it does not curdle for a long time. One of

the dangers in the use of pasteurized milk is the fact that the consumer has no way of telling how old it is. It may appear normal in every way and yet be harmful to the health.

Revis, in a discussion of a paper by Kenwood[11], makes the statement that raw milk never putrefies, pasteurized milk always does. Lederle[12] believes that with the destruction of the ordinary lactic-acid bacteria, which constitute the danger signal of old milk, the souring process is interfered with, and that more serious changes may take place without the knowledge of the consumer. Freudenreich[7] points out the danger of allowing pasteurized milk to stand at high temperatures, due to the growth of spores of the hay and potato bacillus which are not killed during pasteurization. Jensen[9] considers that the use of temperatures suitable to kill *Bacillus tuberculosis* destroys also the lactic-acid bacteria, which, under normal conditions in raw milk, prevent undesirable fermentations. In consequence the commercially pasteurized milk becomes more dangerous than raw milk. He believes that the degree of acidity of raw milk indicates its freshness, while the most dangerous alterations in pasteurized milk often are not visible macroscopically and escape those who control its consumption.

Rickards[17] states:

> Pasteurized milk seems to keep longer, but eventually acquires a strong odor, and really may be said to decompose rather than sour. In nearly every instance we found that pasteurized milk, even when heavily loaded with bacteria, did not decompose until after the nonpasteurized milk taken at the same time had curdled. That such milk is unfit for food, especially for babies, goes without saying.

In connection with this objection to pasteurization Doctor Harrington, in a discussion of a paper by Rotch,[19] states:

> Again, it will make possible the carrying along of milk until, although not sour, it may become more or less poisonous. I believe that dirty milk should be allowed to stay dirty, so that it will sour more quickly, rather than that the lactic-acid ferments shall be destroyed and the commercial life of the milk be prolonged, thus permitting those organisms which are not affected by heat and which are believed to elaborate toxic substances to go on making the milk dangerous.

Another objection to pasteurization is brought out by Pennington and McClintock,[16] who ask this question:

> When milk before pasteurization shows a count of over 1,000,000, is it desirable to permit in a food the toxins and products of metabolism of these many generations of organisms, even though they themselves may be reduced to a very few hundred thousand at the expense frequently of milk enzyms and probably other substances closely connected with its food value and keeping qualities?

Rotch[19] expresses the same sentiment when he says:

> It is a fact that certain organisms are killed by pasteurization, but we can not kill the toxins of these organisms by heat. Simply pasteurizing or sterilizing will still allow the milk to contain elements which are exceedingly dangerous to those who drink it, and especially where young infants are concerned.

Rotch further states that the improper methods of heating now in vogue preserve the milk only some five or six hours longer than the normal raw milk, and that the commercially pasteurized milk after it has turned sour seems to be in a great deal worse condition than when natural souring took place. It may be noted, however, that his views are based on clinical observations rather than experimental data.

Some object to pasteurized milk on account of the careless methods of handling after pasteurization. Pennington and McClintock[16] believe that from the quantitative count alone it would scarcely seem worth while to pasteurize milk of fair quality, since the contamination acquired in bottling is very often sufficient to overbalance the original germ content of the milk. They found that in commercial pasteurizing plants very low counts could be obtained from milk in the heating coils but that it was contaminated in the cooling and bottling, so that sometimes the final count was higher than that of the original milk.

It is greatly feared by some that the adoption of pasteurization will interfere with the extension of sanitary supervision. This opinion is well expressed in the discussion of Rotch's[19] paper by Harrington, who says:

> Pasteurization will put back improvements on the source of the supply and will encourage dirty habits, the farmer understanding that it is not necessary to be so particular since the dirt that gets in is going to be cooked and made harmless.

Another serious objection is that unscrupulous dealers may repasteurize their milk or pasteurize an old milk which ordinarily would not be marketable. It is safe to say, however, that such cases are exceptional. It is often stated also that bacteria increase more rapidly in pasteurized milk than in raw milk, and considering the possibility of infections as shown by Pennington and McClintock[61] the more rapid growth presents a serious objection to pasteurized milk. St. John and Pennington[22] have shown in a few experiments that a more rapid increase in bacterial growth takes place in pasteurized reinfected milk than in raw milk. Their conclusions are based on the ratio of increase. Rickards[17] working on commercially pasteurized milk concludes that on the average bacteria will increase four times as fast in pasteurized milk as in raw milk when kept for twenty-four hours at the temperature of the ice box. His conclusions are drawn from the following table and are based on the ratio of bacterial increase:

	Unpasteurized milk, average count.	Pasteurized milk, average count.	Number of samples.
First day	1,087,000	44,000	87
After 24 hours in ice box	22,617,000	3,691,000	
Per cent increase	2,100	8,400	
Ratio	1	4	

The change in the chemical constituents of milk produced by heat is sometimes the basis of objection to pasteurized milk. Chemical investigations have shown that high temperatures do produce changes in the composition of milk, but the question of the action of lower temperatures for a long period of heating, such as is employed in the "holder" process, is one which demands further study.

As to the effect of feeding heated milk to children, here again authorities are divided. Some believe that malnutrition can often be attributed to the use of pasteurized milk and that rickets and scurvy result from its use. Most authorities, however, agree that pasteurized milk is not injurious, at least as far as the chemical changes produced by heating are concerned.

The objections to pasteurization which are generally accepted as being well founded may be summarized as follows:

1. It is believed that the lactic-acid bacteria in raw milk, which eventually sour the milk, exert a restraining influence on the peptonizing bacteria, which would otherwise cause the putrefaction of the milk. In other words, when milk is pasteurized and subsequently kept free from lactic-acid bacteria, which are easily killed by heat, it will not sour but will putrefy, due to the development of peptonizing bacteria, the spores of which are not destroyed during pasteurization. The peptonizing bacteria, when freed from the restraining influence of the lactic-acid organisms, may increase to large numbers and produce toxins and poisonous decomposition products.

2. The pasteurization of dirty milk, while reducing the bacterial numbers, does not destroy the toxins or other products of bacterial growth.

3. Careless methods of handling after pasteurization may result in serious contamination of the milk.

4. Pasteurization may be used simply to cover up dirty milk; it may encourage dirty methods in production and retard the extension of sanitary supervision.

5. Milk which has not been sold may be pasteurized, or even repasteurized, and its faults hidden.

6. Bacteria may increase more rapidly in pasteurized milk than in raw milk.

7. Undesirable changes may be produced by heating which result in making the milk less digestible, particularly in the case of infants.

It will be seen from the foregoing that much is to be said on both sides of the question, and that further investigation is required, which must be sufficiently thorough and deep so that the conclusions arrived at may be generally accepted.

OBJECT OF THIS INVESTIGATION.

The general object of this work has been to study the bacterial flora of commercially pasteurized and raw market milk. The term "commercially pasteurized" signifies all kinds of such milk and is not intended to indicate the "flash" process, which is distinguished in some cities from perfectly pasteurized milk (meaning that pasteurized by the "holder" process). The endeavor has been made to study the bacteria in the two kinds of milk, pasteurized and raw, when fresh and on each succeeding day as long as the milk was fit for consumption. The special objects have been to determine to what extent the lactic-acid bacteria were destroyed, and to what extent the peptonizing bacteria developed, and to compare the development of various groups of bacteria in pasteurized and raw mlik.

METHODS.

The standards proposed by the committee on standard methods for water analysis[2] have been followed almost exactly, the only change being made in substituting Liebig's beef extract for beef infusion in the preparation of nutrient broth. Two per cent lactose was used in both litmus lactose agar and litmus lactose gelatin. The total count of the milk samples was made on litmus lactose agar plus 1 (Fuller's scale), incubated at 30° C. (86° F.), and recorded after forty-eight hours. On the other hand, the differential count was made from litmus lactose gelatin incubated at 18° C. (64.4° F.) for four days. In using this low temperature the results were more consistent; the low temperature holds the peptonizers in check and gives other forms a chance to develop characteristic colonies. In some cases the gelatin plates had to be counted before four days on account of the large number of liquefying colonies; in other cases it was possible to let the plates incubate as long as five days.

PASTEURIZATION EXPERIMENTS.

The larger part of the work herein described has been with commercial market milk, but it was thought advisable to carry on a few additional experiments in which the pasteurizing process could be controlled. Accordingly, during the summers of 1908 and 1909 experiments were carried on at the field laboratory of the Dairy Division. Experiments were made, using both the "flash" process, which consists of heating flowing milk for from thirty to forty seconds and then cooling, and the "holder" process, where the milk is heated in a tank and held for thirty minutes before cooling.

COMPARISON OF RAW MILK AND MILK PASTEURIZED BY THE "FLASH" PROCESS.

A small pasteurizer of the "flash" type was used in these experiments, and the data obtained are tabulated in Table 1 following.

EXPERIMENT WITH MILK HELD AT 10° C. (50° F.).

The milk used in this experiment was held in the ice chest at 10° C. (50° F.) after pasteurization. The raw milk, it will be noticed, was high in bacteria, as it was produced for butter-making purposes and little care was taken to keep the bacterial numbers down by low temperatures. In each experiment a sample of raw milk was taken in steamed milk bottles together with a sample of the same milk after pasteurization. The samples after collection were plated on litmus lactose agar and incubated for forty-eight hours at 30° C. (86° F.), when the total count was made. The peptonizing bacteria were counted on litmus lactose gelatin incubated at 18° C. (64.4° F.) for four days. The acidity was determined daily and is expressed in percentage of lactic acid.

The milk was examined in this manner until unfit for use. A word of explanation is required concerning the higher count in milk pasteurized at high temperatures than in that heated to lower temperatures; for example, sample No. 11 heated at 82.2° C. (180° F.) shows a higher count after pasteurization than milk heated at any of the other temperatures. This is probably explained by the method of heating. In running a series of different temperatures the highest degree was used first, and while the milk was still flowing through the machine the temperature was lowered in order to obtain samples pasteurized at the other temperatures. The high count was evidently due to the washing out of the machine and the cooler with the milk. It may be mentioned in this connection that the method of collecting samples could not have been changed without interfering with the daily work in the creamery where the pasteurizer was located, and since the method affected only the samples heated at the temperatures higher than those ordinarily used in commercial work it was not considered necessary to repeat the experiments. In all the experiments the machine proved very efficient; the total bacteria in pasteurized milk remained low during the first two days and in many cases for three days.

The difference in temperature of heating seemed to show very little effect on the total numbers after four days. Bacterial reduction during pasteurization may vary greatly with the same temperature in different samples. Compare sample No. 1, raw milk, 1,500,000 bacteria per c. c., reduced to 34,000 in the pasteurized milk, with sample No. 15, raw milk, 13,472,000, reduced to 1,600 per c. c. That means an efficiency in the first case of 97.7 per cent against 99.9 per cent in the last case. The difference in efficiency may not be due to careless methods of controlling the temperature or to contamination, but may be caused by the larger proportion of heat-resisting species of bacteria or bacteria in their spore form.

TABLE 1.—*Comparison of raw and pasteurized ("flash" process) milk held 10° C. (50° F.).*

Sample No.	Kind of milk.	Temperature of pasteurization.	First day.			Second day.		
			Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.	Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.
1	Raw	....	0.16	1,500,000	100,000	0.18	4,500,000	400,000
	Pasteurized	76.7° C. (170° F.)	.17	34,000	1,500	.17	42,000	9,000
2	Raw	....	.16	183,000	32,000	.17	2,600,000	360,00
	Pasteurized	79.45° C. (175° F.)	.15	4,600	1,100	.15	5,200	2,000
3	Raw	....	.15	1,170,000	30,000	.16	53,200,000	1,000,000
	Pasteurized	82.2° C. (180° F.)	.14	209,000	1,000	.14	367,000	20,000
4	Raw	....	.15	10,200,000	2,700,000	.19	86,000,000	1,000,000
	Pasteurized	85° C. (185° F.)	.14	350,000	5,000	.14	5,930,000	30,000
5–6	Raw	....	.18	6,900,000	500,000	.22	156,000,000	4,700,000
5	Pasteurized	71.1° C. (160° F.)	.16	3,630,000	100,000	.16	16,000,000	30,000
6	do	65.6° C. (150° F.)	.16	790,000	....	.16	6,500,000	100,000
7–11	Raw	....	.18	12,800,000	2,600,000	.20	76,600,000	400,000
7	Pasteurized	60° C. (140° F.)	.18	62,150	100	.18	199,000	44,000
8	do	65.6° C. (150° F.)	.18	36,700	500	.18	447,000	280,000
9	do	71.1° C. (160° F.)	.17	15,000	500	.17	30,000	....
10	do	76.7° C. (170° F.)	.16	9,000	1,100	.16	98,000	....
11	do	82.2° C. (180° F.)	.14	562,000	6,000	.14	870,000	10,000
12–16	Raw	....	.18	13,472,000	....	.20	102,900,000	100,000
12	Pasteurized	60° C. (140° F.)	.16	3,450	100	.17	7,100	400
13	do	65.6° C. (150° F.)	.15	2,200	....	.16	5,600	100
14	do	71.1° C. (160° F.)	.15	600	....	.14	2,000	100
15	do	76.7° C. (170° F.)	.14	1,600	....	.16	3,750	100
16	do	82.2° C. (180° F.)	.14	29,300	900	.15	101,000	400

Sample No.	Kind of milk.	Temperature of pasteurization.	Third day.			Fourth day.		
			Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.	Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c
1	Raw	....	0.19	38,000,000	400,000	0.29	49,500,000	600,000
	Pasteurized	76.7° C. (170° F.)	.17	144,000	7,000	.17	3,600,000	400,000
2	Raw	....	.18	10,300,000	1,500,000	.18	47,000,000	4,000,000
	Pasteurized	79.45° C. (175° F.)	.16	32,800	3,000	.16	2,600,000	10,000
3	Raw	....	.22	379,000,000	7,900,000	.37	531,000,000	2,000,000
	Pasteurized	82.2° C. (180° F.)	.16	8,740,000	170,000	.17	82,800,000	....
4	Raw	....	.36	500,000,000	200,000	.64	1,400,000,000	10,000,000
	Pasteurized	85° C. (185° F.)	.19	206,000,000	1,000,000	.57	849,000,000	3,000,000
5–6	Raw	....	.45	1,460,000,000	10,000,000	.64	....	....
5	Pasteurized	71.1° C. (160° F.)	.17	48,000,000	500,000	.19	128,000,000	2,000,000
6	do	65.6° C. (150° F.)	.17	98,000,000	700,000	.23	205,000,000	2,000,000
7–11	Raw	....	.34	380,000,000	1,000,000	.64	980,000,000	....
7	Pasteurized	60° C. (140° F.)	.18	370,000	....	.17	5,650,000	100,000
8	do	65.6° C. (150° F.)	.18	970,000	100,000	.18	13,100,000	....
9	do	71.1° C. (160° F.)	.17	810,000	30,000	.17	13,500,000	100,000
10	do	76.7° C. (170° F.)	.16	70,000	....	.16	6,700,000	200,000
11	do	82.2° C. (180° F.)	.15	11,200,000	50,000	.15	22,000,000	400,000
12–16	Raw	....	.43	370,000,000	100,000	.54	756,000,000	....
12	Pasteurized	60° C. (140° F.)	.16	293,000	900	.18	3,260,000	30,000
13	do	65.6° C. (150° F.)	.16	52,000	1,000	.17	982,000	9,000
14	do	71.1° C. (160° F.)	.17	97,000	1,000	.17	3,480,000	10,000
15	do	76.7° C. (170° F.)	.15	45,000	100	.15	671,000	3,000
16	do	82.2° C. (180° F.)	.15	375,000	3,000	.16	3,970,000	30,000

TABLE 1.—*Comparison of raw and pasteurized ("flash" process) milk held 10° C. (50° F.)*—Continued.

Sample No.	Kind of milk.	Temperature of pasteurization.	Fifth day.			Sixth day.		
			Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.	Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.
1	Raw	...	0.37	131,400,000	400,000	0.63	212,000,000	200,000
	Pasteurized	76.7° C. (170° F.)	.18	4,850,000	1,600,000	.33	65,500,000	13,000,000
2	Raw	...	.24	318,000,000	3,600,000	.44	454,000,000	...
	Pasteurized	79.45° C. (175° F.)	.16	27,200,000	150,000	.18	160,000,000	...
3	Raw	...	.64	790,000,000	...	.67	...	...
	Pasteurized	82.2° C. (180° F.)	.40	740,000,000	...	.64	...	...
4	Raw	...	.71	...	...	...	...	...
	Pasteurized	85° C. (185° F.)	.66	...	...	...	...	...
5-6	Raw	...	...	...	...	...	...	...
5	Pasteurized	71.1° C. (160° F.)	.34	326,000,000	...	.63	...	...
6	do	65.6° C. (150° F.)	.60	650,000,000	...	.69	...	...
7-11	Raw	...	.68	...	...	...	...	...
7	Pasteurized	60° C. (140° F.)	.16	28,600,000	500,000	.22	72,000,000	1,000,000
8	do	65.6° C. (150° F.)	.16	44,000,000	700,000	.18	91,000,000	2,000,000
9	do	71.1° C. (160° F.)	.18	35,800,000	1,200,000	.33	79,000,000	2,000,000
10	do	76.7° C. (170° F.)	.17	28,600,000	800,000	.20	57,000,000	2,000,000
11	do	82.2° C. (180° F.)	.17	100,000,000	1,100,000	.31	488,000,000	7,000,000
12-16	Raw	...	.63	1,019,000,000	...	.63	960,000,000	...
12	Pasteurized	60° C. (140° F.)	.18	65,500,000	700,000	.21	348,000,000	1,000,000
13	do	65.6° C. (150° F.)	.18	32,100,000	300,000	.19	96,000,000	1,000,000
14	do	71.1° C. (160° F.)	.17	15,000,000	140,000	.19	227,000,000	1,500,000
15	do	76.7° C. (170° F.)	.16	9,000,000	100,000	.18	45,500,000	600,000
16	do	82.2° C. (180° F.)	.18	19,600,000	1,100,000	.27	597,000,000	3,000,000

Sample No.	Kind of milk.	Temperature of pasteurization.	Seventh day.			Remarks.
			Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.	
1	Raw	...	0.79	...	...	Slightly sour on fifth day.
	Pasteurized	76.7° C. (170° F.)	.52	293,000,000	8,000,000	Slightly sour on seventh day.
2	Raw	...	.45	488,000,000	300,000	Slightly bitter on sixth day; slightly sour on seventh day.
	Pasteurized	79.45° C. (175° F.)	.24	240,000,000	24,000,000	Slightly bitter on sixth day; slightly sour on eighth day.
3	Raw	...	...	...	...	Curdled on sixth day.
	Pasteurized	82.2° C. (180° F.)	...	...	...	Slightly sour on fifth day.
4	Raw	...	...	...	...	Sour on fourth day.
	Pasteurized	85° C. (185° F.)	...	...	...	Do.
5-6	Raw	...	...	...	...	Curdled and sour on fourth day.
5	Pasteurized	71.1° C. (160° F.)	...	...	...	Curdled and sour on sixth day.
6	do	65.6° C. (150° F.)	...	...	...	Slightly sour on fifth day.
7-11	Raw	...	...	...	...	Sour on fourth day; coagulated on sixth day.
7	Pasteurized	60° C. (140° F.)	.46	230,000,000	36,000,000	Slightly bitter on sixth day. sour on eighth day.
8	do	65.6° C. (150° F.)	.27	235,000,000	17,000,000	Do.
9	do	71.1° C. (160° F.)	.45	301,000,000	29,000,000	Do.
10	do	76.7° C. (170° F.)	.35	570,000,000	29,000,000	Do.
11	do	82.2° C. (180° F.)	.47	612,000,000	2,000,000	Do.
12-16	Raw	...	69	...	...	Sour on fourth day.
12	Pasteurized	60° C. (140° F.)	.29	...	...	Slightly sour on eighth day.
13	do	65.6° C. (150° F.)	...	...	...	Sweet on eighth day.
14	do	71.1° C. (160° F.)	.22	...	...	Do.
15	do	76.7° C. (170° F.)	.19	...	...	Do.
16	do	82.2° C. (180° F.)	.38	...	...	Slightly sour on eighth day.

THE INCREASE IN PEPTONIZING BACTERIA.

The peptonizing bacteria in milks held at 10° C. (50° F.) are shown in Table 2.

The most striking feature is the low number of peptonizers, especially during the first three days; in every case the peptonizers represented only a small percentage of the total bacteria. This may be seen by comparison with Table 1.

During the first three days the peptonizing bacteria in the pasteurized milk were very low as compared with those in the raw milk, and were much lower on the fourth and fifth days in sample No. 2, and also on the fourth day in sample No. 4. The low count of peptonizers in the raw milk was undoubtedly due to the large numbers of lactic-acid bacteria, which exercise a restraining influence on the development of the peptonizing forms. These figures indicate, as far as these experiments are concerned, that the peptonizing bacteria do not play the important part in pasteurized milk that is credited to them.

TABLE 2.—*Number of peptonizing bacteria per cubic centimeter in raw and pasteurized ("flash" process) milk held at 10° C. (50° F.).*

Sample No.	Kind of milk.	Temperature of pasteurization.	Days.					
			1.	2.	3.	4.	5.	6.
5–6	Raw	....	500,000	4,700,000	10,000,000	....	....	....
5	Pasteurized	71.1° C. (160° F.)	100,000	30,000	500,000	2,000,000	....	....
6	do	65.6° C. (150° F.)	....	100,000	700,000	2,000,000	....	....
1	Raw	....	100,000	400,000	400,000	600,000	400,000	200,000
	Pasteurized	76.7° C. (170° F.)	1,500	9,000	7,000	400,000	1,600,000	13,000,000
2	Raw	....	32,000	360,000	1,500,000	4,000,000	3,600,000	....
	Pasteurized	79.4° C. (175° F.)	1,100	2,000	3,000	10,000	150,000	....
3	Raw	....	30,000	1,000,000	7,900,000	2,000,000	....	....
	Pasteurized	82.2° C. (180° F.)	1,000	20,000	170,000	....	....	....
4	Raw	....	2,700,000	1,000,000	200,000	10,000,000	....	....
	Pasteurized	85° C. (185° F.)	5,000	30,000	1,000,000	3,000,000	....	....
7–11	Raw	....	2,600,000	400,000	1,000,000	....	....	....
7	Pasteurized	60° C. (140° F.)	100	44,000	....	100,000	500,000	1,000,000
8	do	65.6° C. (150° F.)	500	280,000	100,000	....	700,000	2,000,000
9	do	71.1° C. (160° F.)	500	....	30,000	100,000	1,200,000	2,000,000
10	do	76.7° C. (170° F.)	1,100	....	....	200,000	800,000	2,000,000
11	do	82.2° C. (180° F.)	6,000	10,000	50,000	400,000	1,100,000	7,000,000
12–16	Raw	....	....	100,000	100,000	....	....	....
12	Pasteurized	60° C. (140° F.)	100	400	900	30,000	700,000	1,000,000
13	do	65.6° C. (150° F.)	....	100	1,000	9,000	300,000	1,000,000
14	do	71.1° C. (160° F.)	....	100	1,000	10,000	140,000	1,500,000
15	do	76.7° C. (170° F.)	....	100	100	3,000	100,000	600,000
16	do	82.2° C. (180° F.)	900	400	3,000	30,000	1,100,000	3,000,000

EXPERIMENTS WITH MILK HELD AT ROOM TEMPERATURE.

Table 3 shows the results of two experiments in which the pasteurized milk was held at room temperature. The temperature ranged from 22° to 25° C. (71.6° to 77° F.) during the experiments.

In the first series—samples 17 to 21—the raw milk remained sweet until the second day. The pasteurized milks all soured with normal acid curds on the third day. In the second series—samples 22 to 26—where the counts were all higher, both the raw and the pasteurized milk soured in twenty-four hours with solid curds and a little gas.

TABLE 3.—*Comparison of raw and pasteurized ("flash" process) milk held at 22–25° C. (71.6–77° F.).*

Sample No.	Kind of milk.	Temperature of pasteurization.	First day.				Second day.		
			Acidity.		Total bacteria per c. c.	Peptonizing bacteria per c. c.	Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.
17–21	Raw.......	....	0.20		1,030,000	250,000	0.84	....	....
17	Pasteurized.	60° C.(140° F.).	.17		10,000	8,000	.22	46,600,000	10,500,000
18	.....do......	65.6° C. (150° F.).	.18		300	100	.18	13,000,000	1,100,000
19	.....do......	71.1° C. (160° F.).	.18		300	....	.19	14,000,000	1,600,000
20	.....do......	76.7° C. (170° F.).	.17		(a)	....	.18	7,140,000	1,100,000
21	.....do......	82.2° C. (180° F.).	.15		300	200	.17	9,860,000	1,200,000
			9 a.m.	*3 p.m.*					
22–26	Raw.......	....	0.19	0.43	63,250,000	(b)	.92	650,000,000	(b)
22	Pasteurized.	60° C.(140° F.).	.15	.18	385,300		.72	435,000,000	
23	.....do......	65.6° C. (150° F.).	.16	.17	127,800		.78	386,000,000	
24	.....do......	71.1° C. (160° F.).	.16	.18	38,500		.80	100,000,000	
25	.....do......	76.7° C. (170° F.).	.17	.17	31,800		.75	558,000,000	
26	.....do......	82.2° C. (180° F.).	.15	.15	419,700		.79	1,132,000,000	

Sample No.	Kind of milk.	Temperature of pasteurization.	Third day.			Remarks.
			Acidity.	Total bacteria per c. c.	Peptonizing bacteria per c. c.	
17–21	Raw.......	....	......	....	....	Coagulated on second day.
17	Pasteurized.	60° C. (140° F.).	0.86	1,560,000,000	....	Sour on third day; solid curd.
18	.....do......	65.6° C. (150° F.)	.83	1,450,000,000	1,000,000	Do.
19	.....do......	71.1° C. (160° F.)	.63	1,050,000,000	....	Coagulated and sour on third day.
20	.....do......	76.7° C. (170° F.)	.62	790,000,000	1,000,000	Do.
21	.....do......	82.2° C. (180° F.)	.52	735,000,000	....	Do.
22–26	Raw.......	....	......	....	....	Coagulated with gas third day.
22	Pasteurized.	60° C. (140° F.).	......	....	....	Coagulated third day; slight amount of gas.
23	.....do......	65.6° C. (150° F.)	......	....	....	Do.
24	.....do......	71.1°C. (160° F.)	......	....	....	Do.
25	.....do......	76.7° C. (170° F.)	......	....	....	Do.
26	.....do......	82.2° C. (180° F.)	......	....	....	Do.

[a] 0 in 100 dilutions.

[b] Gelatin plates lost.

THE INCREASE IN ACIDITY.

The formation of acid is shown graphically in figure 1.

In this experiment two series of samples of raw and pasteurized milk were heated at different temperatures, one set being held at 10° C. (50° F.) and the other at room temperature, 22° to 28° C. (71.6° to 82.4° F.). Figure 1, *A*, shows the increase in acidity in the milk held at 10° C. (50° F.). It is seen that the acidity in the raw milk began to increase during the first twenty-four hours and continued rapidly, reaching 0.44 per cent on the third day. The pasteurized milk did not change in acidity until the fifth day in one sample and the sixth day in the other samples, but the acidity then increased. Of the pasteurized samples it will be seen that the acidity began to increase first in the milk pasteurized at 82.2° C. (180° F.), the highest temperature. This may be explained in the same way as were the higher counts in Table 1.

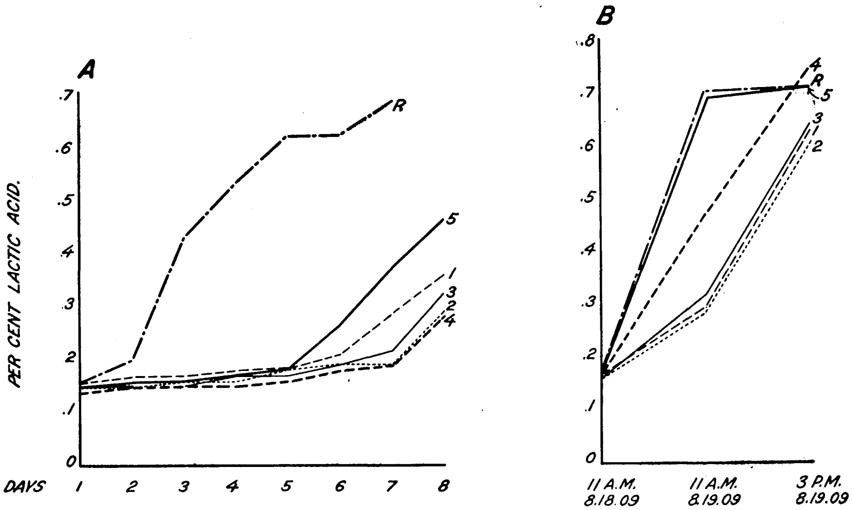


FIG. 1.—Pasteurization experiments. Comparison of acidity of pasteurized ("flash" process) and raw milk. *A*, milk held at 10° C. (50° F.); *B*, milk held at room temperature 22° to 28° C. (71.6° to 82.4° F.). Samples for both series collected from pasteurizer at same time. *R*, raw milk; *1*, milk pasteurized at 60° C. (140° F.); *2*, milk pasteurized at 65.6° C. (150° F.); *3*, milk pasteurized at 71.1° C. (160° F.); *4*, milk pasteurized at 76.7 C. (170° F.); *5*, milk pasteurized at 82.2° C. (180° F.).

The acidity in the other series of samples, held at room temperature, is shown in figure 1, *B*. The raw milk and the milk pasteurized at 82.2° C. (180° F.) soured in twenty-four hours, having an acidity of approximately 0.7 per cent. The same explanation as before accounts for the acidity of the pasteurized sample. In the other samples the acidity began to increase at once, and at 3 o'clock on the second day the acidities were all above 0.60 per cent. The souring in the pasteurized milk held at 10° C. (50° F.) was delayed until the sixth day. In similar milk held at room temperature the souring was delayed only a few hours.

These experiments indicate that pasteurization does not prevent milk from souring, but merely delays the process.

COMPARISON OF RAW MILK AND MILK PASTEURIZED BY THE "HOLDER" PROCESS.

A few experiments were made using the "holder" process for pasteurizing. The milk was heated in the same "flash" machine used in the preceding experiments, from which it flowed into a steamed-covered can, where it was held. The temperature of the milk dropped only 2 degrees (Centigrade) during the holding. The results are shown in Tables 4 and 5.

REDUCTION OF BACTERIA DURING THE HOLDING PROCESS.

Ten minutes were required to fill the holding can, and that time must be added to all the holding periods as shown in Table 4. It may be seen that twenty minutes' holding was almost as efficient as the forty minutes' holding as shown in the last column of the table.

Another experiment was carried out under the same conditions except that the milk was pasteurized in a jacketed can and held for varying lengths of time. The results are shown in Table 5. As in the previous experiment, twenty minutes' holding was nearly as efficient as forty minutes' holding. The two samples heated to 60° C. (140° F.) and held for forty minutes, also the two heated to 65.6° C. (150° F.), all curdled with an acid curd in forty-eight hours when held at room temperature. On the other hand, one of the two samples heated to 71.1° C. (160° F.) curdled with a rennet curd after twenty-four hours at room temperature, while the other curdled after forty-eight hours with an acidity of 0.41 per cent and was partly digested.

TABLE 4.—*Showing reduction of bacteria per cubic centimeter during pasteurization by the "holder" process.*

Bacteria in raw milk.	Pasteurizing temperature.	Sample taken directly from pasteurizer.	Sample taken when holding can was full.	After holding in can—					
				5 minutes.	10 minutes.	15 minutes.	20 minutes.	25 minutes.	30 minutes.
5,850,000	60° C. (140° F.)	....	1,189,000	239,000	117,000	57,000	192,000	153,000	46,900
24,900,000	65.6° C. (150° F.)	....	768,000	481,000	129,000	....	127,000	39,800	45,000
3,200,000	71.1° C. (160° F.)	4,200	....	....	4,200	....	2,100	3,000	1,600
35,000,000	76.7° C. (170° F.)	....	3,450	200	500	(a)	200	200	80

[a] 0 in 100 dilutions.

TABLE 5.—*Showing reduction of bacteria per cubic centimeter by heating and holding milk in the same can.*

Sample No.	Bacteria in raw milk.	Pasteurizing temperature.	Sample taken when temperature reached pasteurizing temperature.	After holding in can—		
				5 minutes.	10 minutes.	15 minutes.
1	21,000,000	60° C. (140° F.)	4,032,000	3,743,000	2,394,000	514,000
2	3,150,000	.....do	337,000	47,000	28,000	24,000
3	19,400,000	65.6° C. (150° F.)	596,000	70,000	18,000	2,000
4	4,340,000	.....do	185,000	63,000	62,000	14,600
5	536,000	71.1° C. (160° F.)	41,000	9,000	100	100
6	70,000,000	.....do	120,000	1,430	3,020	460

Sample No	Bacteria in raw milk.	Pasteurizing temperature.	After holding in can—			
			20 minutes.	25 minutes.	30 minutes.	Remarks.
1	21,000,000	60° C. (140° F.)	1,386,000	320,000	1,071,000	Curdled after 48 hours at room temperature; 81 per cent acid; sour, smooth curd.
2	3,150,000	.....do	50,000	33,000	32,000	Curdled, 48 hours; 0.42 per cent acid; smooth curd.
3	19,400,000	65.6° C. (150° F.)	5,750	5,100	12,000	Curdled, 48 hours; 0.52 per cent acid.
4	4,340,000	.....do	14,000	26,900	....	Curdled, 48 hours at 30° C.; 64 per cent acid.
5	536,000	71.1° C. (160° F.)	200	100	100	Curdled after 24 hours at room temperature; sweet rennet curd; acidity 0.17 per cent.
6	70,000,000	.....do	250	640	770	Curdled, 48 hours; acidity 0.41 per cent; partly digested.

These experiments show that a high temperature for a considerable period is required to prevent souring. It is evident, too, that peptonizing bacteria are of no more importance than in raw milk, for the milk must be held four or five days before their numbers in pasteurized milk are as great as those in raw milk. The results also indicate that milk always sours when pasteurized under conditions that would prevail in commercial work, although the souring is delayed.

EXAMINATION OF PASTEURIZED AND RAW MILK UNDER COMMERCIAL CONDITIONS.

The experiments which have been described indicated what might be expected of commercially pasteurized milk in general and suggested the procedure for the following work.

THE PASTEURIZED MILK SUPPLY OF A SMALL CITY.

An examination was first made of pasteurized milk in a small community, as it was thought that the conditions in a small city might differ from those of the larger ones.

The pasteurized milk used in this case was obtained from a plant that had been in operation about three weeks. Before pasteurizing, the milk was run through a separator from which both the skim milk and the cream flowed directly into a heater where it was pasteurized. Two bottles of milk were delivered daily to a private residence and then taken directly to the laboratory. Thus the work was carried on without the knowledge of the milk company, and in this way milk was obtained which exactly represented the city supply. When the milk was received at the laboratory it was well mixed and a portion poured off to facilitate the shaking, in order to get a representative bacteriological sample. One bottle was held at 10° C. (50° F.) and the other at 22° C. to 25° C. (71.6° to 77° F.). The data obtained are tabulated in Tables I and II in the appendix.

It may be advisable to give a word of explanation in regard to "0" days which is used in the tables. In this and later tables "0" days is taken as the day the milk was received at the laboratory; this does not mean that the milk was not a day old, but that it was the time the consumer would receive it. It is probable that in many cases this milk was twenty-four hours old, dating from the time of pasteurization. As may be seen from the tables, the bacteria were divided into three groups—peptonizing, lactic acid, and alkali or inert bacteria.

Under peptonizing bacteria were classed all forms which liquefied gelatin. But it must be remembered that all bacteria which liquefy gelatin do not necessarily digest casein, nor do all casein peptonizers cause the liquefaction of gelatin; however, it is safe to assume that the majority of bacteria that digest casein appear on the gelatin plate as liquefiers.

All bacteria that gave red colonies with litmus were classed under the head of lactic-acid bacteria. On account of the scope of this definition a number of gas formers were probably included and in the tables this has been indicated by adding "lactis aerogenes" or the letters L A. after the count.

In the group called alkali-formers or inert bacteria were classed all those forms which do not noticeably produce acid or liquefy gelatin. In some cases the organisms produced enough alkali to form distinct bluish colonies, but usually there were very few which were active enough to show any alkaline reaction and for this reason the alkali and inert bacteria were classed under one head. In many instances slow acid-producing organisms may not have produced red colonies on the gelatin plates and so would be classed under the group of alkali or inert bacteria. The percentages of the different groups together with the total counts are tabulated in Tables III and IV of the appendix. In these tables the total counts were on litmus lactose gelatin and the percentages are in terms of the bacterial count. The differential count was also made on litmus lactose gelatin plates.

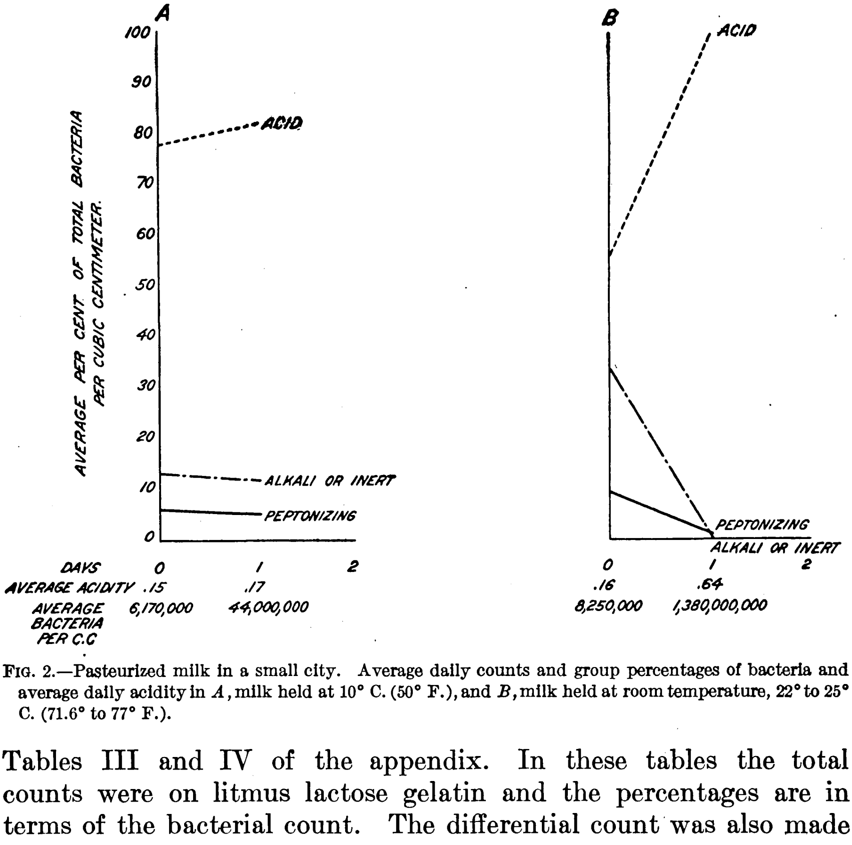


FIG. 2.—Pasteurized milk in a small city. Average daily counts and group percentages of bacteria and average daily acidity in *A*, milk held at 10° C. (50° F.), and *B*, milk held at room temperature, 22° to 25° C. (71.6° to 77° F.).

The percentages, total counts, and daily acidity have been averaged and are shown in Table 6 below, and in order to show the relation of the groups more plainly these results are given in graphic form in figure 2.

TABLE 6.—*Pasteurized milk in a small city—Average counts and group percentages of bacteria and acidity, compiled from data in Tables I, II, III, and IV of the appendix.*

Acidity and bacteria.	Milk held at 10° C. (50° F.).		Milk held at 22° C. to 25° C. (71.6-77° F.).	
	0 days.	1 day.	0 days.	1 day.
Acidity, in percentage of lactic acid	0.15	0.17	0.16	0.64
Bacteria per cubic centimeter.......number..	6,170,000	44,000,000	8,250,000	1,380,000,000
Peptonizing bacteria.......per cent..	6.72	5.18	9.92	1.14
Lactic-acid bacteria.......do....	78.71	82.79	56.76	99.03
Alkali or inert bacteria.......do....	13.39	12.00	33.97	.19

While it may be seen that sometimes the group percentages of the individual samples did not exactly follow the average percentages, it is believed that the average figures show the true relation from day to day.

Unfortunately, in the first part of this work the milk was examined for two days only, and the curve is short for that reason. An examination of the curve of the milk held at 10° C. (50° F.) shows a high initial percentage of lactic-acid bacteria, which increased on the second day. The peptonizing and alkali or inert bacteria were low and the per cent of the total decreased on the second day. It must be understood that where the curve is a downward one it does not mean a decrease in actual numbers but simply a lower proportion of the total number. For example, take the peptonizing bacteria. On the first day these were approximately 6 per cent of 6,170,000 bacteria per cubic centimeter, while on the second day they were approximately 5 per cent of 44,000,000 per cubic centimeter. During that time there was a corresponding increase in the numbers and proportion of the lactic-acid bacteria.

The curve of the milk held at room temperature shows the same relative position of the three groups. At the time the consumer would receive it the average group proportion was: Peptonizers, 9.92 per cent; lactic-acid bacteria, 56.76 per cent; alkali and inert forms, 33.97 per cent. After holding twenty-four hours at room temperature the proportion of acid bacteria rapidly increased to 99.03 per cent, while the alkali or inert forms decreased to 0.19 per cent and the peptonizers to 1.14 per cent. The average acidity was 0.64 per cent, indicating a sour milk.

The result of the examination of this commercially pasteurized milk shows that the lactic-acid bacteria were not destroyed during pasteurization and that the souring at room temperature produced normal acid curds.

A STUDY OF PASTEURIZED AND RAW MILK IN BOSTON.

For a study of pasteurized and raw milk in large cities, Boston, Mass., was first chosen. Milk from various sources was examined during the winter of 1908–9 and also during the month of June, 1909. The complete data obtained are tabulated in Tables V to X of the appendix.

The samples of milk in every case were delivered at private residences or bought at stores, so that they represent actual commercial conditions. In other words, the milk in every case represented the condition of market milk when received by the consumer. The "0" days count shows the condition of the milk when delivered. Milk purchased in stores—"loose" or "dipped" milk—was collected in clean milk bottles, as would be used by the average housewife. Differential counts were made on litmus-lactose gelatin as in the previous work. The bacteria were divided into three groups as in the former case, and the percentages of each in every sample is shown in Table VIII of the appendix. The figures have been averaged, together with the total bacteria and acidity, and are tabulated in Table 7 below. As in the previous work, these averages are shown graphically in figure 3.

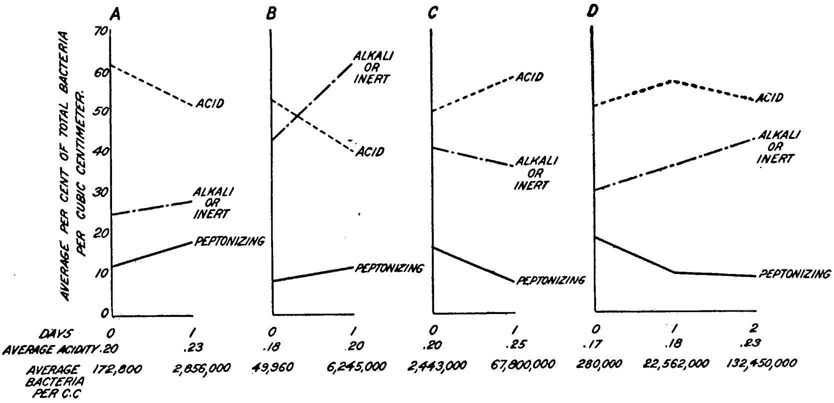


FIG. 3.—Pasteurized and raw milk in Boston, Mass., examined during November and December, 1908, and January, 1909. Average daily counts and group percentages of bacteria and average daily acidity in pasteurized and raw milk held at 10° C. (50° F.). *A*, pasteurized milk from dairy B, "flash" process, 60° to 65.6° C. (140° to 150° F.); *B*, pasteurized milk from dairy A, "holder" process, 60° to 65.6° C. (140° to 150° F.); *C*, pasteurized milk from dairy C, "flash" process, 71.1° to 73.8° C. (160° to 165° F.); *D*, raw milk from dairy G.

TABLE 7.—*Raw and pasteurized milk at Boston, Mass.—Average counts and group percentages of bacteria and acidity, compiled from data in Tables V and VIII of the appendix—Milk held at 10° C. (50° F.).*

Acidity and bacteria.	Dairy A, pasteurized.		Dairy B, pasteurized.	
	0 days.	1 day.	0 days.	1 day.
Acidity, in percentage of lactic acid	0.18	0.20	0.20	0.23
Bacteria per c. c. ....Number..	49,960	[a] 6,245,000	172,800	2,856,000
Peptonizing bacteria........Per cent..	8.80	11.90	12.18	18.58
Lactic-acid bacteria........do....	53.35	40.88	62.50	52.76
Alkali or inert bacteria........do....	43.45	62.36	25.31	28.65

Acidity and bacteria.	Dairy C, pasteurized.		Dairy G, raw.		
	0 days.	1 day.	0 days.	1 day.	2 days.
Acidity, in percentage of lactic acid	0.20	0.25	0.17	0.18	0.23
Bacteria per c. c. ....Number..	2,443,000	67,800,000	280,000	22,562,000	132,450,000
Peptonizing bacteria........Per cent..	16.06	7.87	18.63	9.31	8.44
Lactic-acid bacteria........do....	50.36	58.20	51.84	57.83	52.23
Alkali or inert bacteria........do....	41.24	36.81	30.12	36.25	42.41

[a] High average due to one high count.

At this time it was not thought necessary to examine the milk after the second day, since milk in the home is usually consumed during the first twenty-four hours. Later, however, the advantage of a longer holding was noted, so that raw milk from dairy G was held for forty-eight hours. Figure 3 shows the curves of the milk held at 10° C. (50° F.).

Milk from dairy B was pasteurized by the "flash" process and from dairy A by the "holder" process. In both cases the milk was delivered in bottles. At dairy C the "flash" process was used and the pasteurized milk sold from cans in stores. Raw milk from dairy G was inspected milk of higher quality than ordinary market milk. By inspected milk is meant milk which is constantly being examined by a bacteriologist and produced from herds which are under the supervision of a veterinarian.

WINTER MILK.

A comparison of the curves of dairy A and dairy B shows that the peptonizing bacteria were present in the smallest proportion in all cases. The best pasteurized milk was from dairy A, as shown by the count, and the curve shows a higher proportion of alkali or inert forms than does the milk from dairy B, also the percentages of lactic-acid bacteria were lower in dairy A. On the second day the percentage of alkali or inert bacteria had increased in the milk from dairy A so that they were present in greater proportion than the lactic-acid bacteria.

The curve of dairy B shows a decrease in the percentage of lactic-acid bacteria and an increase in the alkali or inert forms, but the original ratio still held. If the curves of dairies A and B are compared with the curve of dairy C, the milk from which showed a very high average count, it will be seen that the ratios were approximately the same on the first day, but changed on the second day. The proportion of acid bacteria increased instead of decreasing, and the alkali or inert forms decreased instead of increasing. The peptonizing bacteria also decreased in percentage instead of increasing slightly as they did in the other pasteurized milk.

The curves of group percentages of the raw milk show about the same initial group proportion as the pasteurized milk. The percentage of the lactic-acid bacteria was approximately the same as in the pasteurized milk. On the second day there was an increase in the proportion of acid bacteria, which, however, decreased on the third day. The percentage of alkali or inert forms increased steadily during the first two days, while the proportion of peptonizers decreased.

It may be seen that the relation of the three groups of bacteria was about the same in the pasteurized and raw milk during the first twenty-four hours except in the case of dairy A, where at the end of twenty-four hours the largest proportion of the bacteria consisted of alkali or inert forms. But although the proportion was lower, the actual number of alkali or inert bacteria in the raw milk at the end of twenty-four hours was greater than the number in milk from dairy A.

In regard to the peptonizing bacteria in pasteurized milk from dairies A and B, their actual numbers as shown by the average percentages of total count during the first twenty-four hours were lower than in the raw milk from dairy G. The pasteurized milk sold in cans from dairy C, however, showed a higher number of peptonizing bacteria than was found in the raw milk, both in the initial count and after twenty-four hours.

A number of samples of milk from dairies A and B were held at room temperature and examined in the same manner as those held at 10° C. (50° F.). The percentages of the three groups of bacteria and the total count are shown in Table IX of the appendix. The average of the percentages, together with the average total count and average acidity, are shown in Table 8 below, and are graphically represented in figure 4.

TABLE 8.—*Pasteurized milk at Boston, Mass.—Average counts and group percentages of bacteria and acidity, compiled from data in Table IX of the appendix—Milk held at 21.1° C. (70° F.).*

Acidity and bacteria.	Dairy A, pasteurized.		Dairy B, pasteurized.	
	0 days.	1 day.	0 days.	1 day.
Acidity, in percentage of lactic acid	0.20	0.26	0.22	0.34
Bacteria per c. c. ....number	72,000	104,000.000	170,000	300,137,000
Peptonizing bacteria ....per cent	5.43	12.44	10.79	3.69
Lactic-acid bacteria ....do	61.99	59.74	65.01	76.74
Alkali or inert bacteria ....do	37.21	27.80	24.20	21.99

The curves explain themselves and only a few words need be said regarding them. In the curve of milk from dairy B the lactic-acid bacteria formed 65.01 per cent of the total, and increased to 76.74 per cent in twenty-four hours. The acid bacteria in milk from dairy A constituted 61.99 per cent of the total bacteria and decreased to 59.74 per cent. The alkali or inert forms were lower in proportion in the curve of dairy B than in dairy A, although they decreased in both in twenty-four hours. The peptonizers represented the smallest group in both cases. It will be noticed that the average bacterial count of milk from dairy A was less than one-half that of dairy B, and that with the lower count the lactic-acid group curve is downward, while in the higher count the curve is upward.

In regard to the milk examined in Boston during the winter it may be said that pasteurized milk from dairies A and B was equally as good bacteriologically as raw milk from an inspected dairy. The bacterial numbers were lower during the first twenty-four hours in the pasteurized milk, and the relative proportions of the three groups of bacteria, namely, peptonizing, lactic acid, and alkali or inert bacteria, were approximately the same. On the other hand, pasteurized milk from dairy C, which was sold from cans in stores, was very high in bacteria although the same relative proportion of groups held as in the milk from other sources.

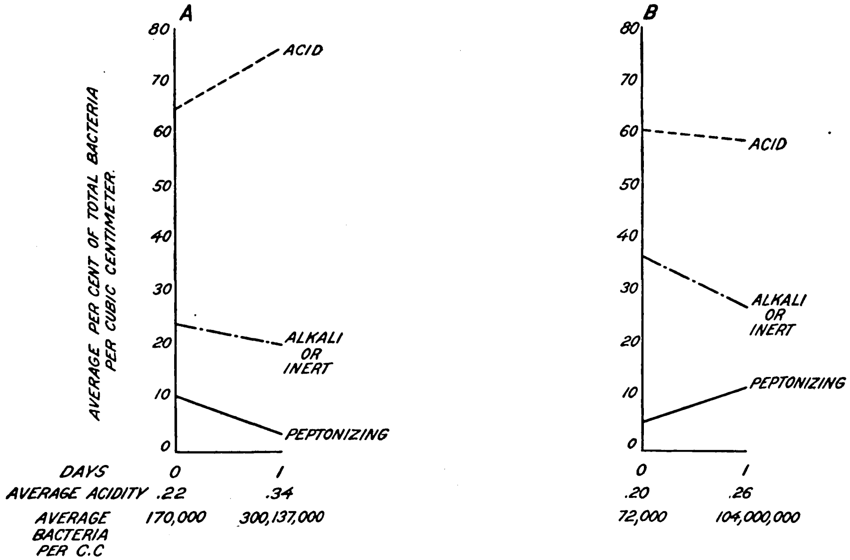


FIG. 4.—Pasteurized milk in Boston, Mass., examined during November and December, 1908, and January, 1909. Average daily counts and group percentages of bacteria and average daily acidity of pasteurized milk held at room temperature, 21.1° C. (70° F.). *A*, milk from dairy B, "flash" process, 60° to 65.6° C. (140° to 150° F.); *B*, milk from dairy A, "holder" process," 60° to 65.6° C. (140° to 150° F.).

SUMMER MILK.

In order to study the condition of pasteurized milk in Boston in the summer, samples of milk from dairy A and raw milk from dairies E and F and from stores were examined during June, 1909. The same methods were employed as in the winter work. Table X in the appendix shows the total counts on litmus lactose gelatin and the percentages of the three groups of bacteria. All samples were held at 10° C. (50° F.). The averages are shown in Table 9 below, and also in figure 5.

TABLE 9.—*Raw and pasteurized milk at Boston, Mass., in summer—Average counts and group percentages of bacteria and acidity, compiled from data in Tables VII and X of the appendix—Milk held at 10° C. (50° F.).*

Acidity and bacteria.	Dairies E and F and stores, raw.		Dairy A, pasteurized.		
	0 days.	1 day.	0 days.	1 day.	2 days.
Acidity, in percentage of lactic acid	0.17	0.24	0.15	0.15	0.19
Bacteria per c. c. ... number	10,883,000	157,607,000	251,500	30,095,000	173,500,000
Peptonizing bacteria ... per cent	8.71	6.59	14.71	12.16	9.19
Lactic-acid bacteria ... do	57.60	62.17	22.00	31.56	71.04
Alkali or inert bacteria ... do	36.21	35.18	66.81	64.28	25.30

It may be seen from the diagram that during the first twenty-four hours the three groups were not in the same relative proportion. In the pasteurized milk on the initial count 66.81 per cent of the total bacteria were alkali or inert forms, while in the raw milk the percentage was only 36.21 per cent. The curve of the alkali or inert forms is downward in both cases, and after forty-eight hours the relation of the alkali or inert forms to the acid group in the pasteurized milk was just reversed, the greater proportion of the total bacteria being lactic-acid forms. It is evident that in this series of samples a small proportion of lactic-acid bacteria was left, which soon increased so as to form the majority of the total bacteria. The curves of the peptonizing bacteria are downward in both cases. While the percentage was slightly higher in the pasteurized milk, it can be plainly seen from the average count that the actual number of peptonizers in the pasteurized milk was less than in the raw milk. The same thing

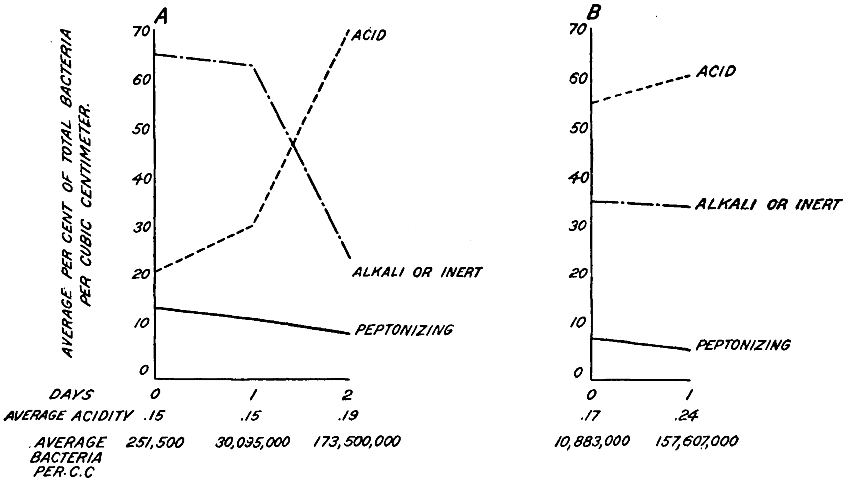


FIG. 5.—Pasteurized and raw milk in Boston, Mass., examined during June, 1909. Average daily counts and group percentages of bacteria and average daily acidity of pasteurized and raw milk held at 10° C. (50° F.). *A*, Pasteurized milk from dairy A, "holder" process, 60° to 65.6° C. (140° to 150° F.); *B*, Raw milk from stores and dairies E and F.

was true of the alkali or inert forms. Take, for example, the average initial count in the pasteurized milk, 251,000, of which 66.81 per cent were alkali or inert forms, which means approximately 168,000 per cubic centimeter. Compare that number with the initial count in the raw milk, which is 36.21 per cent of 10,883,000, or approximately 3,940,000. Even after twenty-four hours the same thing was true. The pasteurized milk had 64.28 per cent of 30,095,000, or approximately 19,345,000, as compared with 35.18 per cent of 157,607,000, or approximately 55,440,000, alkali or inert bacteria in the raw milk.

All of the bottles of pasteurized milk and most of the bottles of raw milk were delivered at a private residence at from 2 to 4 o'clock in the morning and were in many cases placed on the back fence, so that after sunrise they were directly in the sun's rays until taken into the house at 7 o'clock, which means that almost all the milk was exposed for several hours at a high temperautre, and explains the high bacterial count. Such methods of delivery, however, represented the average condition.

A few samples of raw and pasteurized milk were collected at the plant of dairy B. Unfortunately, during examination the gelatin plates from most of the samples melted, due to the very hot weather. The counts on litmus lactose agar and a few differential counts on gelatin, however, may be found in Table VII of the appendix. The samples of both raw and pasteurized milk were collected at the plant and taken to the laboratory without icing, and as the temperature was high, the high counts may be to some extent due to that fact. The raw milk represented the regular supply which was delivered to the consumer, while the pasteurized milk was practically the same milk heated. The samples were collected in steamed bottles just before and after pasteurization, then placed in the refrigerator of the dairy for twenty-four hours before examination, so as to duplicate commercial conditions. The total counts on lactose agar are shown below:

Raw.	Pasteurized.
14,500,000	1,760,000
25,000,000	1,450,000
8,900,000	6,300,000
48,000,000	1,210,000
12,600,000	215,000
32,000,000	16,900,000
	4,095,000
	1,940,000

From the differential counts in Table VII it will be seen that the group relation was about the same in the raw and the pasteurized milk. The milk was pasteurized by the "flash" process at a temperature of about 62.8° C. (145° F.). While the pasteurized milk was evidently better than the raw milk, the pasteurization was not efficient, due to the low temperature used. It may thus be seen that under summer conditions the pasteurized milk examined was equally good, if not better, from a bacteriological point of view than the raw milk.

A STUDY OF PASTEURIZED AND RAW MILK IN NEW YORK CITY.

New York was chosen for the third representative city for the study of the pasteurized milk problem. The milk samples were delivered to or collected by private individuals so as to get representative market conditions. They were held at two temperatures, 10° C. (50° F.) and 20° C. (68° F.), and the differential bacteriological count was divided into three groups, all of which are represented in the data as shown in Tables XI and XII of the appendix. The total count in the milk held at 10° C. (50° F.) and the percentages of the differential groups on gelatin have been tabulated and shown in Table XIII. The average counts and group percentages of bacteria are given in Table 10 below, and these averages are graphically shown in figures 6, 7, and 8.

TABLE 10.—*Raw and pasteurized milk in New York City—Average counts and group percentages of bacteria and acidity, compiled from data in Tables XI and XIII of the appendix—Milk held at 10° C. (50° F.).*

DAIRY H, PASTEURIZED.

Acidity and bacteria.	0 days.	1 day.	2 days.	3 days.	4 days.	5 days.	6 days.
Acidity, in percentage of lactic acid	0.19	0.19	0.20	0.20	0.27	0.33	0.53
Bacteria per c. c..number	16,100	43,000	2,033,000	12,470,000	28,200,000	100,250,000	310,000,000
Peptonizing bacteria, per cent	3.71	17.53	16.05	11.35	4.74	5.58	2.29
Lactic-acid bacteria, per cent	30.26	6.79	24.18	39.06	28.60	51.68	77.32
Alkali or inert bacteria, per cent	62.32	78.31	69.51	57.91	66.76	41.82	20.87

DAIRIES K AND M, PASTEURIZED.

Acidity and bacteria.	0 days.	1 day.	2 days.	3 days.
Acidity, in percentage of lactic acid	0.19	0.19	0.20	0.25
Bacteria per c. c. ....number	21,400	558,000	5,317,000	72,600,000
Peptonizing bacteria ....per cent	11.60	9.04	17.97	12.05
Lactic-acid bacteria ....do	29.56	41.83	26.67	45.84
Alkali or inert bacteria ....do	61.76	50.62	57.93	44.70

RAW.

Acidity and bacteria.	0 days.	1 day.	2 days.	3 days.	4 days.
Acidity, in percentage of lactic acid	0.18	0.18	0.19	0.21	0.21
Bacteria per c. c. ....number	174,000	1,120,000	6,200,000	61,200,000	78,000,000
Peptonizing bacteria ....per cent	14.02	15.85	37.34	20.81	20.94
Lactic-acid bacteria ....do	56.89	48.37	20.93	45.25	43.21
Alkali or inert bacteria ....do	29.27	36.65	46.00	34.08	39.67

Dairies H, K, and M represent three of the largest milk companies in New York which pasteurize their milk. The raw milk examined came from dairies P and N, which are two of the largest companies supplying raw milk. A few samples of raw milk were purchased in stores. The milk was held and examined for several days.

THE DIFFERENTIAL BACTERIOLOGICAL CONTENT.

It may be seen from the diagrams that in the pasteurized milk the alkali or inert bacteria constituted the larger portion of the flora during the first few days, or until the acidity began to increase, at which time the percentage of lactic-acid bacteria took the lead. On the other hand, in the raw milk the lactic-acid forms were present in the greatest proportion on the initial count, but later on the other forms increased so that the lactic-acid bacteria were in the minority.

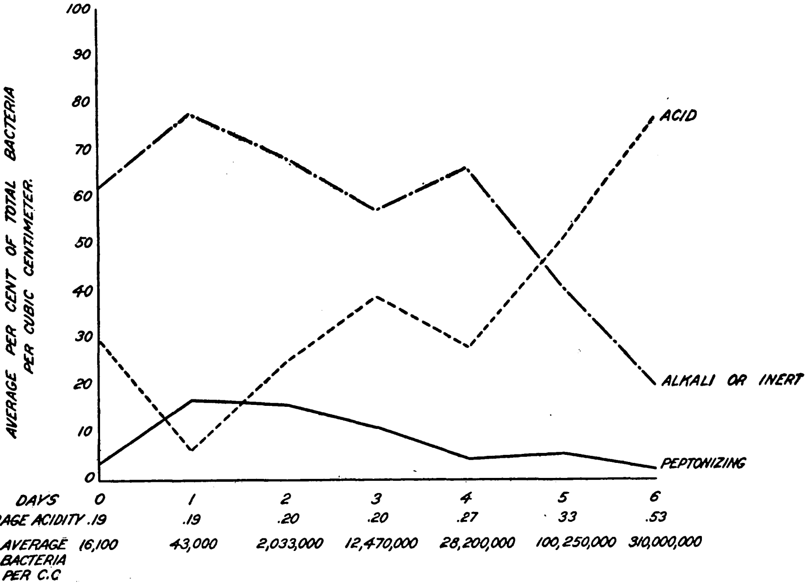


FIG. 6.—Pasteurized milk in New York City, "holder" process, examined during February and March, 1909. Average daily counts and group percentages of bacteria and average daily acidity in milk from dairy H, pasteurized at 60° to 65.6° C. (140° to 150° F.) and held for six days at 10° C. (50° F.).

They, however, later increased to a point where they again formed the largest group.

A more careful analysis of each diagram shows numerous interesting points. Figure 6 shows the average counts, daily acidity, and group percentages of milk from dairy H. The milk was pasteurized by the "holder" process. One striking point was the low average counts even after twenty-four hours holding. The pasteurizing process was evidently very efficient, and this series of samples represents what can be done along the lines of pasteurization. Along with the low counts will be noticed a reversal of group ratios as compared with Boston; that is to say, a large proportion of alkali or inert bacteria was present rather than lactic-acid bacteria, as was the case in Boston with pasteurized milk of a higher initial count and also with raw milk. If the curves of the three groups are followed in figure 6 it will be seen that the proportion of alkali or inert forms increased slightly, then gradually decreased, until on the fifth day their percentage was lower than that of the lactic-acid bacteria. The latter, after a slight decrease in the first twenty-four hours, steadily increased until the sixth day, when they constituted 77.32 per cent of the total bacteria. The peptonizers were in the smallest proportion and increased slightly during the first twenty-four hours and then gradually decreased.

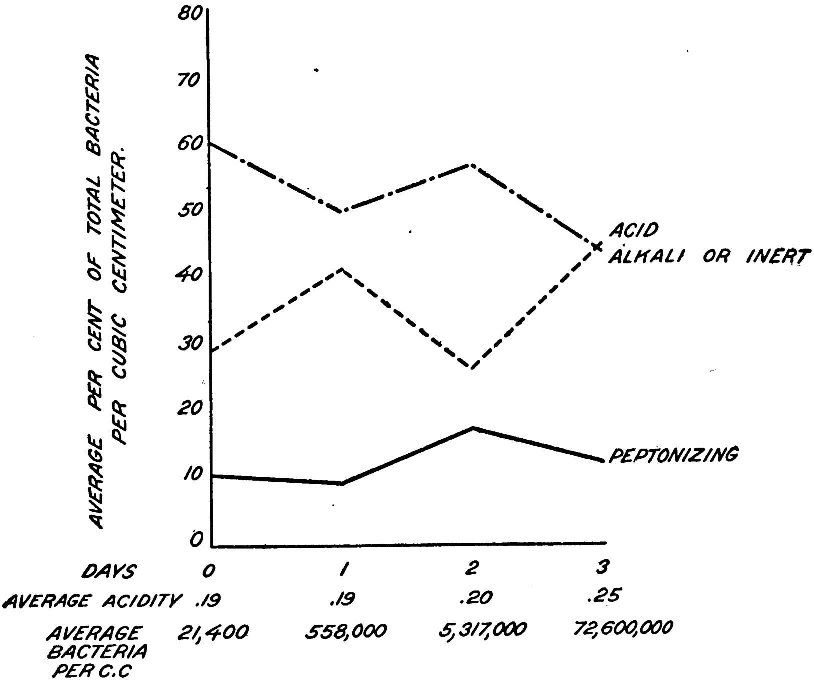


FIG. 7.—Pasteurized milk in New York City, "flash" process, examined during February and March, 1909. Average daily counts and group percentages of bacteria and average daily acidity in milk from dairies K and M, pasteurized at 70° to 71.1° C. (158° to 160° F.) and held for three days at 10° C. (50° F.).

Figure 7 shows the averages from milk pasteurized by the "flash" process. The curves of the groups are practically the same as those in figure 6. The alkali or inert forms were present in the greatest proportion and gradually decreased as the milk was held. The curve of the acid group is upward, while the peptonizers remained in relatively the same proportion. The variations in all these curves are due to the averaging in of some sample which had a very high count in some one group, so the curve of one group is raised and another one lowered. This point is shown in the curve in figure 7, where on the second day the alkali curve rises while the acid curve is correspondingly lowered.

Figure 8 shows the group percentages of raw milk held at 10° C. (50° F.). In the initial count there were 56.89 per cent of lactic-acid bacteria, as compared with 29.27 per cent of alkali or inert forms and 14.02 per cent of peptonizers. The curves show how the relative proportion held during four days. It is possible that the inverted ratio on the second day would not hold if more samples had been examined.

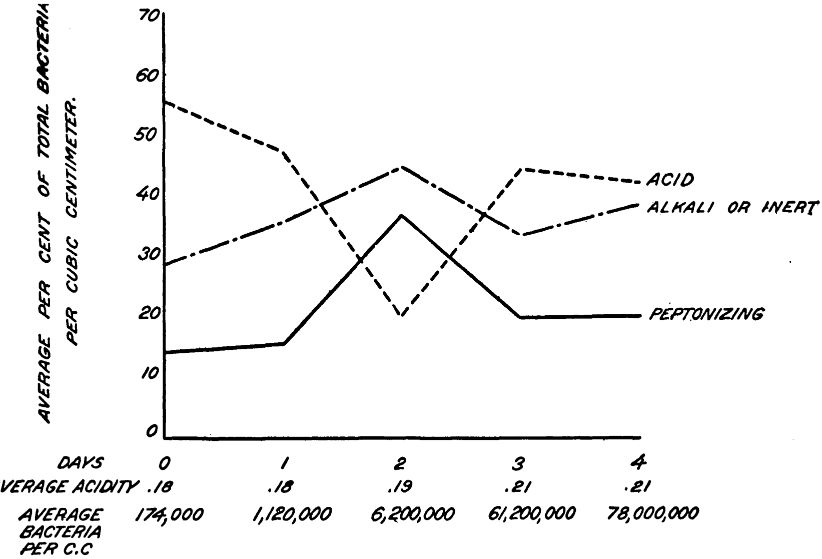


FIG. 8.—Raw milk in New York City, examined during February and March, 1909. Average daily counts and group percentages of bacteria and average daily acidity of milk held for four days at 10° C. (50° F.).

Other samples of milk from the same dairies were held at room temperature and examined in the same manner as those held at 10° C. (50° F.). Table XIV in the appendix shows the total counts and group percentages, and Table 11 below gives the average total counts, acidity, and group percentages. The averages are shown graphically in figure 9.

TABLE 11.—*Raw and pasteurized milk in New York City—Average counts and group percentages of bacteria and acidity, compiled from data in Tables XII and XIV of the appendix—Milk held at room temperature, 20° C. (68° F.).*

Acidity and bacteria.	Dairy H, pasteurized.			Dairies K and M, pasteurized.		Raw.	
	0 days.	1 day.	2 days.	0 days.	1 day.	0 days.	1 day.
Acidity, in percentage of lactic acid	0.20	0.20	0.53	0.17	0.22	0.18	0.28
Bacteria per c. c., number	12,300	6,006,000	317,000,000	13,000	20,900,000	129,000	84,000,000
Peptonizing bacteria, per cent	2.84	15.40	1.93	14.70	5.71	18.13	15.41
Lactic-acid bacteria, per cent	23.27	19.55	72.91	27.60	50.89	47.18	47.89
Alkali or inert bacteria, per cent	73.85	64.90	25.14	64.52	48.94	34.67	38.61

Little need be said regarding the curves, as they explain themselves. In the pasteurized milk the percentage of lactic-acid bacteria was small on the initial count, but in the case of dairy H after forty-eight hours, and dairies K and M after twenty-four hours, the majority of the total bacteria were of the lactic-acid group. In the raw milk the lactic-acid forms constituted the largest proportion on the initial count and the relative proportion of the three groups did not change. The actual numbers of the alkali or inert bacteria and the peptonizers were much less in the pasteurized milk than in the raw milk. It will also be noticed that, as was the case with the pasteurized milk held at 10° C. (50° F.), the percentage of the lactic-acid group reached that of the alkali or inert group more quickly in milk pasteurized by the "flash" process. This is seen in the curves of the milk from dairies H, K, and M in figures 6, 7, and 9. This is probably due to the fact that the lactic forms which survive the "holder" process grow slower than those left by the "flash" process. That lactic-acid bacteria do survive pasteurization will be shown later. The statement is often made that pasteurized milk does not sour, but this work does not support such a view.

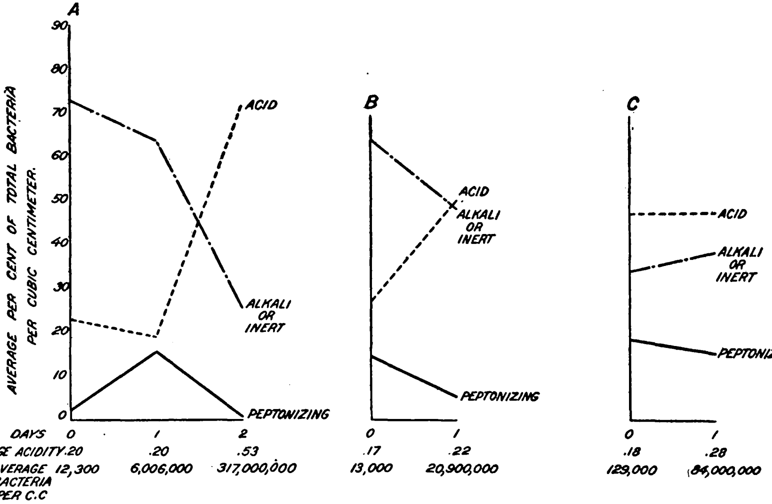


FIG. 9.—Pasteurized and raw milk in New York City. Average daily counts and group percentages of bacteria and average daily acidity of milk held at room temperature, 20° C. (68° F.). *A*, pasteurized milk from dairy H, "holder" process, 60° to 65.6° C. (140° to 150° F.); *B*, pasteurized milk from dairies K and M, "flash" process, 70° to 71.1° C. (158° to 160° F.); *C*, raw milk.

DEVELOPMENT OF ACIDITY.

In figure 10 are given four curves, showing the acidity of various kinds of milk. Each curve, except the one for certified milk, represents the average daily acidity of a number of samples. The curve of acidity of certified milk represents one sample. All the samples of pasteurized and raw milk were low in bacteria initially and represented the best quality of milk of their respective kinds. In the samples held at 10° C. (50° F.) it may be seen that the pasteurized and raw milk soured at approximately the same time, while the certified remained sweet some few days longer. The same holds true in the acidity curves when the milk was held at room temperature. In the various tables of complete data in this paper will be found remarks as to the taste of milk after holding. Often a sample of milk has been marked as having an "old" taste which in many cases was so strong as to render the milk unfit for consumption. This taste is considered by many to be characteristic of pasteurized milk. This work has shown, however, that the "old" taste occurs in any milk, raw or pasteurized, which is low enough in bacteria to remain sweet for several days when held at low temperatures, and is probably due to the alkali or inert bacteria. The certified milk examined gave a putrid taste and odor on the seventh day, although not sour until the ninth or tenth day.

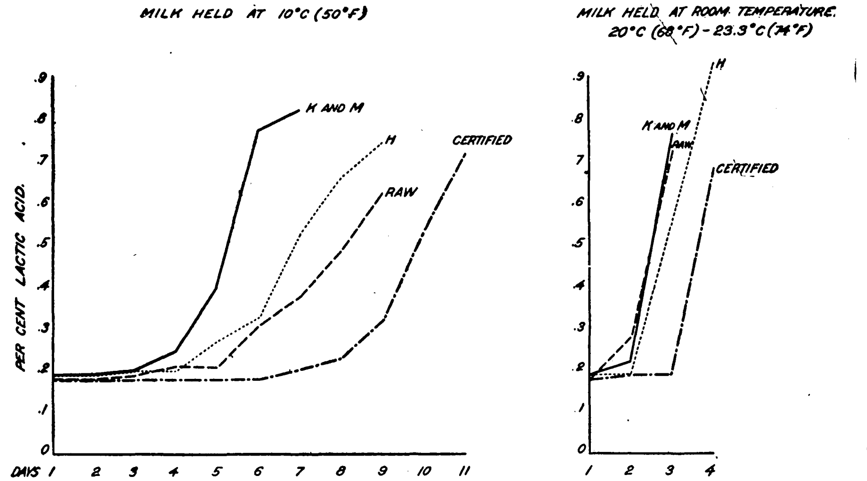


FIG. 10.—Pasteurized and raw milk in New York City. Comparison of average daily acidity at 10° C. (50° F.) and at room temperature, 20° to 23.3° C. (68° to 74° F.). *K and M*, milk pasteurized by "flash" process from dairies K and M; *H*, milk pasteurized by "holder" process from dairy H; *Raw*, raw milk from stores and dairies N and P; *Certified*, one sample of certified milk.

GROWTH OF PEPTONIZING BACTERIA.

In Table 12 is tabulated the number of peptonizing bacteria in the pasteurized and raw milk in New York held at 10° C. (50° F.).

The table shows that the numbers of peptonizing bacteria in pasteurized milk were as low, if not lower, than in raw milk after twenty-four hours, and that they were much lower after forty-eight hours. Even when older the numbers of peptonizers were nearly equal in the two kinds of milk. If it is assumed that the peptonizing bacteria are not injurious in raw milk, then they can not be considered injurious in pasteurized milk, since their numbers in both kinds of milk are about the same.

TABLE 12.—*Raw and pasteurized milk in New York City—Comparison of growth of peptonizing bacteria—Milk held at 10° C. (50° F.).*

PASTEURIZED MILK.

"HOLDER" PROCESS, 60° TO 65° C. (140° TO 150° F.).

Sample No.	0 days.	1 day.	2 days.	3 days	4 days.	5 days.	6 days.
201	600	1,000	50,000	1,600,000	......	2,000,000	......
203	(a)	......	900,000	......	1,100,000	......	3,000,000
205	600	1,000	......	100,000	......	900,000	6,000,000
207	200	......	14,000	......	1,300,000	7,000,000	2,000,000
209	......	900	......	170,000	1,000,000	4,000,000	8,000,000
211	1,000	......	270,000	1,000,000	3,000,000	3,000,000	......
213	53,000	(b)	10,000	4,000,000	1,000,000	......	......
215	1,000	22,000	800,000	4,000,000	......	......	......
217	400	4,000	1,000,000	1,000,000	......	......	......
219	300	14,000	100,000	......	......	......	......
221	300	110,000	......	......	......	......	......

"FLASH" PROCESS, 71.1° C. (160° F.).

Sample No.	0 days.	1 day.	2 days.	3 days	4 days.	5 days.	6 days.
225	1,000	(c)	300,000	4,000,000	4,000,000	......	......
227	1,300	10,000	700,000	......	......	......	......
229	800	6,000	3,000,000	......	......	......	......
231	500	......	......	1,000,000	......	......	......
233	800	......	......	1,100,000	......	......	......
235	1,400	......	100,000	600,000	......	......	......

PASTEURIZED IN COUNTRY.

"FLASH" PROCESS, 70° C. (158° F.).

Sample No.	0 days.	1 day.	2 days.	3 days	4 days.	5 days.	6 days.
237	300	90,000	200,000	......	......	......	......
239	21,000	4,000,000	240,000	8,000,000	......	......	......
241	900	130,000	......	19,000,000	......	......	......
243	1,200	10,000	500,000	2,000,000	......	......	......
245	3,800	......	(d)	2,000,000	......	......	......

RAW MILK.

BOTTLED MILK.

Sample No.	0 days.	1 day.	2 days.	3 days	4 days.	5 days.	6 days.
253	7,000	60,000	4,000,000	......	3,000,000	......	......
261	1,100	(c)	1,200,000	7,000,000	15,000,000	......	......
255	12,000	30,000	1,300,000	5,000,000	......	22,000,000	......
257	30,000	20,000	2,700,000	......	15,000,000	28,000,000	......
259	50,000	1,300,000	......	2,000,000	18,000,000	......	......

DIFFERENT MILK FROM STORES.

Sample No.	0 days.	1 day.	2 days.	3 days	4 days.	5 days.	6 days.
263	2,800,000	8,000,000	17,000,000	9,000,000	......	......	......
265	13,000	170,000	3,600,000	23,000,000	25,000,000	30,000	......
267	2,000	80,000	2,300,000	15,000,000	......	......	......
269	2,200	100,000	12,000,000	......	......	......	......

[a] 0 in 100 dilutions. [b] 0 in 1,000 dilutions. [c] 0 in 10,000 dilutions. [d] 0 in 100,000 dilutions.

RAW MILK IN WASHINGTON, D. C.

After completing the investigation of pasteurized milk in Boston and New York it was thought advisable to obtain a good, clean, raw milk in order to show more conclusively the relation of the three bacterial groups. Two sources were drawn upon in Washington, D. C., and the results obtained are compiled in Tables XV and XVI of the appendix.

In order to make the entire investigation analogous, the same methods were employed with the exception of making no total count on lactose agar. The samples from dairy T were delivered at a private residence and then taken directly to the laboratory and plated. The samples from dairy S were bought on the open market. The samples were held at two temperatures, as before—10° C. (50° F.), and room temperature—and the bacterial counts divided into the same groups. In Table XVII the counts and percentages of the different groups are tabulated, and the averages in Table 13 below are drawn directly from these percentages. These averages are shown graphically in figure 11.

TABLE 13.—*Raw milk at Washington, D. C.—Average counts and group percentages and acidity, compiled from data in Table XVII of the appendix—Samples from dairy T milk held at 10° C. (50° F.).*

Acidity and bacteria.	0 days.	1 day.	2 days.	3 days.	4 days.	5 days.	6 days.
Acidity, in percentage of lactic acid	0.16	0.17	0.18	0.27	0.42	0.56	0.66
Bacteria per c. c., number	186,000	8,200,000	54,500,000	236,000,000	352,000,000	557,000,000	519,000,000
Peptonizing bacteria, per cent	22.03	23.12	23.05	21.24	19.89	13.95	9.89
Lactic-acid bacteria, per cent	29.81	20.50	18.91	34.04	32.63	25.93	56.04
Alkali or inert bacteria, per cent	48.85	56.03	58.03	43.99	47.54	60.08	34.05

The milk described in Table 13 and figure 11 was held at 10° C. (50° F.), and represents a good grade. The average initial count is rather high, mostly due to one sample with an especially high count. In order to make the curve smooth the group percentages for the fifth day were not plotted. It may be seen that the curves correspond to those of the pasteurized milk in New York shown in figures 6 and 7; that is to say, the majority of the bacteria on the initial count were of the group of alkali or inert forms which gradually decreased. The lactic-acid group increased while the peptonizers decreased. If the curves are followed carefully it may be noted that the group of alkali or inert forms increased for two days, then decreased until the sixth day, when the lactic-acid bacteria were in the majority. The lactic forms decreased during the first forty-eight hours, then increased to 56.04 per cent of the total bacteria on the sixth day. The peptonizers were present initially in a larger percentage than is usual in the milk previously examined, but they gradually decreased. The acidity increased slowly, and if Table XV of the appendix is consulted it will be seen that on the third and later days many of the samples were described as having an "old" and in some cases a slightly putrid taste.

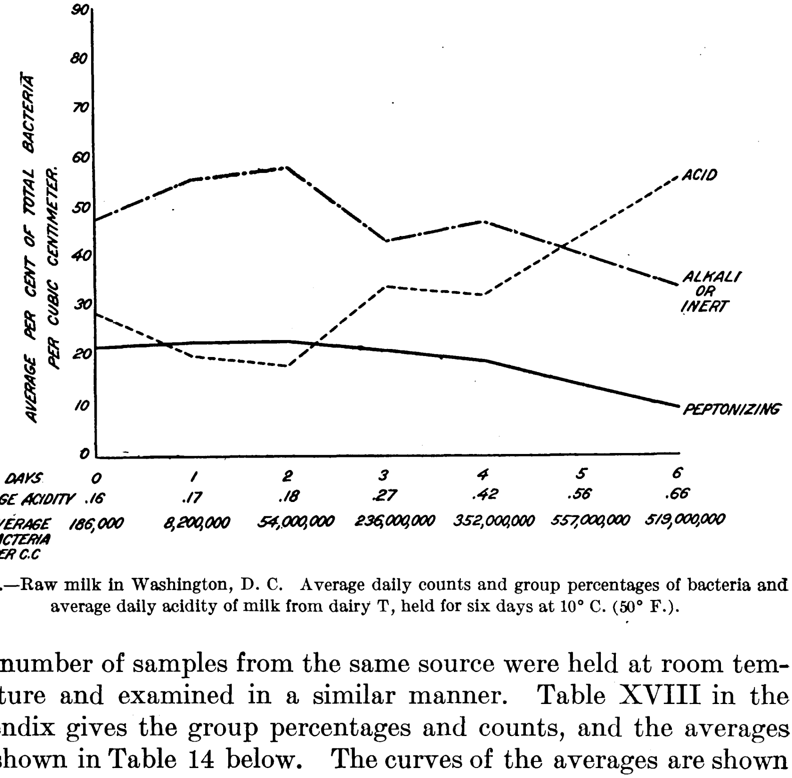


FIG. 11.—Raw milk in Washington, D. C. Average daily counts and group percentages of bacteria and average daily acidity of milk from dairy T, held for six days at 10° C. (50° F.).

A number of samples from the same source were held at room temperature and examined in a similar manner. Table XVIII in the appendix gives the group percentages and counts, and the averages are shown in Table 14 below. The curves of the averages are shown in figure 12.

TABLE 14.—*Raw milk at Washington, D. C.—Average counts and group percentages and acidity, compiled from data in Table XVIII of the appendix—Samples from dairy T—Milk held at room temperature, 20° C. (68° F.).*

Acidity and bacteria.	0 days.	1 day.	2 days.
Acidity, in percentage of lactic acid	0.16	0.21	0.61
Bacteria per c. c. ....number..	96,500	92,160,000	585,000,000
Peptonizing bacteria........per cent..	14.67	24.17	10.15
Lactic-acid bacteria........do....	35.38	27.78	54.50
Alkali or inert bacteria........do....	50.68	48.03	35.95

The curves approximate very closely those of the pasteurized milk from dairy H, New York (see fig. 9). The percentage of the group of alkali or inert forms was closer to that of the lactic-acid group than in the case of the pasteurized milk, but they were in the majority, and so the relative proportion of the three groups was the same in both cases. As in the pasteurized milk from dairy H, the proportion held for twenty-four hours, after which the milk soured and the majority of the bacteria were in the lactic-acid group. The per cent of peptonizers increased during the first twenty-four hours and then decreased, but as in all previous samples constituted the minority group.

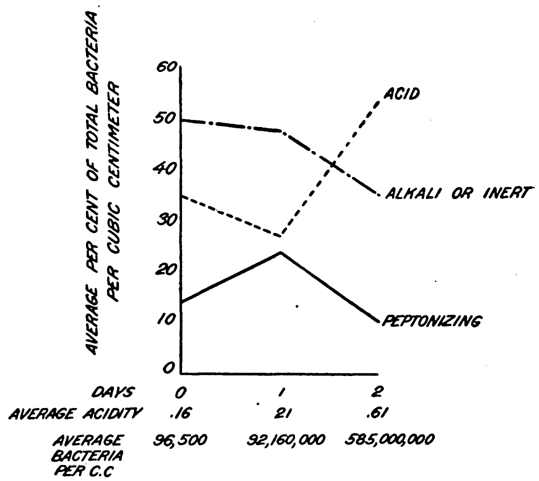


FIG. 12.—Raw milk in Washington, D. C. Average daily counts and group percentages of bacteria and average daily acidity of milk from dairy T, held for two days at room temperature, 20° C. (68° F.).

DISCUSSION OF RESULTS OBTAINED FROM ANALYSIS OF COMMERCIAL MILK.

A COMPARISON OF VARIOUS GRADES OF PASTEURIZED AND RAW MILK.

Since the bacterial flora of milk is believed to be changed after heating, it may be of interest to compare a few of the various grades of milk previously described. Figure 13 shows the group percentage curves of a good pasteurized milk as compared with a clean, raw milk held at 10° C. (50° F.).

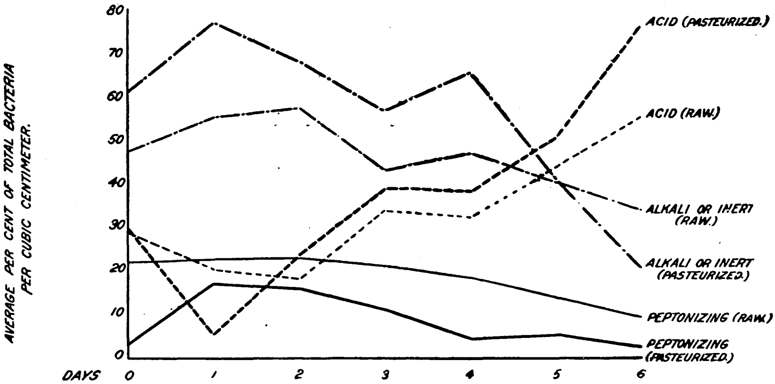


FIG. 13.—Comparison of high-grade pasteurized and raw milk held for six days at 10° C. (50° F.) Average daily counts and group percentages of bacteria.

In general it may be said that the relative proportion of the groups in a good grade of pasteurized milk is approximately the same as that in a clean, raw milk. The alkali or inert forms in both cases form the majority of the bacteria, and increase in their proportion during the first day and then gradually decrease until the fifth day, when their percentage is lower than that of the lactic-acid group. The acid bacteria constitute on the initial count from 20 to 30 per cent of the total, and after a decrease in proportion during the first twenty-four hours they gradually increase to form the largest portion of the bacterial content on the sixth day. In both the pasteurized and the raw milk the peptonizers are the smallest group; they increase slightly in proportion and then gradually decrease. The group percentages are much closer in clean, raw milk than in good, pasteurized milk, as may be seen from the diagram.

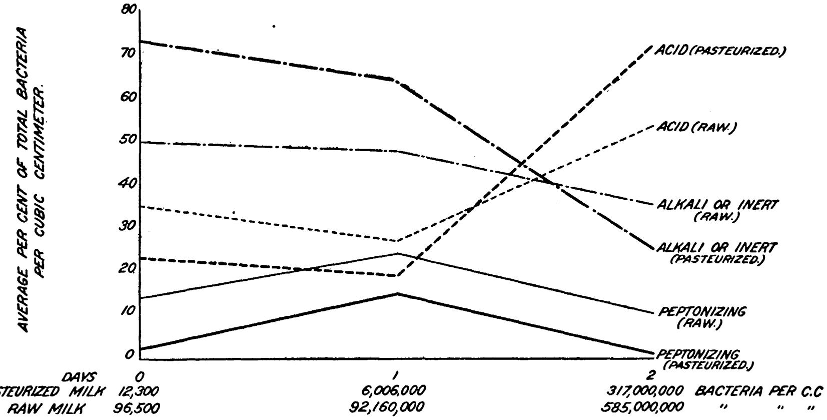


FIG. 14.—Comparison of high-grade pasteurized and raw milk held for two days at room temperature, 20° C. (68° F.). Average daily counts and group percentages of bacteria.

When the same grades are held at room temperature—20° C. (68° F.)—the group percentages stand in the same relative proportion in both the pasteurized and the raw milk (see fig. 14).

The groups stand in the same positions initially as in the series at 10° C. (50° F.), but their proportion in both cases changes after twenty-four hours. The change is the same as at the lower temperature, except that the lactic-acid group reach the ascendancy at the end of forty-eight hours instead of on the sixth day.

It is evident from these curves that, bacteriologically, a clean, raw milk is not superior to a good grade of pasteurized milk either in regard to the proportion of the various groups or to the actual bacterial numbers.

Having compared a good grade of pasteurized milk with a clean, raw milk, a good pasteurized milk may now be compared with an inspected milk of a little higher bacterial count than the clean milk and also with a less efficiently pasteurized milk.

In figure 15 *A* represents a clean, pasteurized milk, *B* a fair grade of inspected raw milk, and *C* an inferior grade of pasteurized milk. The most striking feature is the difference in percentages of the alkali or inert groups and the acid groups in the three kinds of milk. *B* and *C* are approximately alike, while in *A* the position of the acid and alkali or inert groups is inverted. That means that in less efficiently pasteurized milk less of the acid group are destroyed, so that after pasteurization the group percentages correspond closely to the proportion of the three groups in ordinary raw milk. On the other hand, in the best grades of pasteurized milk the acid bacteria are reduced so that the majority of bacteria are alkali or inert forms, as is the case in clean, raw milk. If *B* and *C* are compared it is hard to see how the raw milk can be called superior, bacteriologically, even to the less efficiently pasteurized milk.

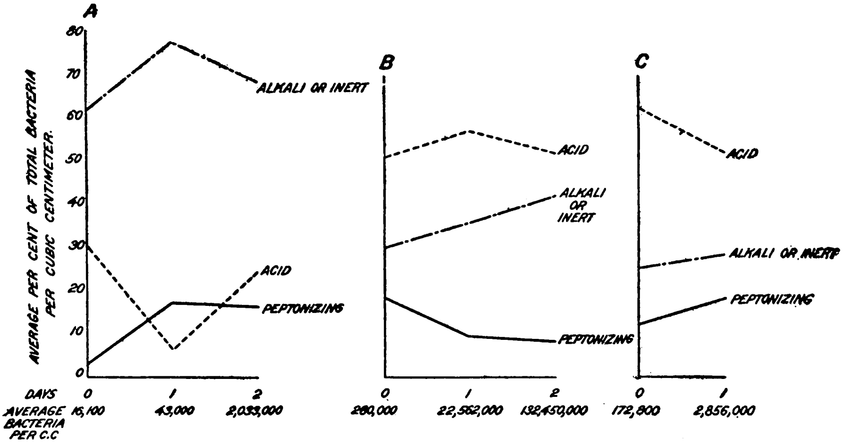


FIG. 15.—Comparison of high-grade and low-grade pasteurized milk with raw milk. Average daily counts and group percentages of bacteria in samples held at 10° C. (50° F.). *A*, good grade of pasteurized milk: *B*, fair grade of inspected raw milk; C, inferior grade of pasteurized milk.

THE ABSENCE OF ACID BACTERIA IN BEST GRADES OF RAW MILK.

It has been shown in figure 13 that a clean, raw milk may have only a small percentage of lactic-acid bacteria, and this point may be more thoroughly shown in the following tables.

TABLE 15.—*Showing daily percentage of lactic acid and other bacteria in clean, raw milk.*

SAMPLE 251, CERTIFIED MILK HELD FOR SEVEN DAYS AT 10° C. (50° F.).

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c.c. on litmus lactose gelatin.	Peptonizing bacteria.	Lactic-acid bacteria.	Alkali or inert bacteria.
			Number.	*Per cent.*	*Per cent.*	*Per cent.*
251	0	0.18	300	....	....	100.00
	1	.18	....	....	....	....
	2	.18	2,000	50.00	....	50.00
	3	.18	17,100,000	2.33	....	97.66
	4	.18	15,000,000	20.00	....	80.00
	5	.18	24,700,000	9.71	....	90.28
	6	....	....	....	....	....
	7	.23	53,000,000	16.98	5.66	77.35

SAMPLE 252, CERTIFIED MILK HELD FOR THREE DAYS AT ROOM TEMPERATURE, 20° C. (68° F.).

252	0	0.18	200	....	....	100.00
	1	.19	10,000	....	....	100.00
	2	.18	23,000,000	60.86	13.04	26.08
	3	.69	481,000,000	2.91	65.90	31.18

Table 15 gives the total count, daily acidity, and group percentages in a sample of certified milk held at 10° C. (50° F.) and a duplicate sample at 20° C. (68° F.). In the milk held at the low temperature there was only a slight increase in acid during seven days. However, the bacterial content increased to 53,000,000 per cubic centimeter, of which only 5.66 per cent were of the lactic-acid group. Up to the seventh day no organisms of the acid group were found; the majority of the bacteria belonged to the group of alkali or inert forms, while on some days there was a considerable percentage of peptonizers. The fact that no lactic-acid bacteria were found on the plates during the first six days does not necessarily indicate that none were present, but merely shows that their numbers were so small that they did not show up at the dilutions made necessary by the numbers of the other groups. In the milk held at room temperature similar conditions existed during the first two days; that is to say, lactic-acid bacteria were absent, and in this special case peptonizers also. On the third day acid bacteria appeared and on the fourth day were in the majority.

The fact that the cleaner the milk the lower will be the percentage of lactic-acid bacteria is further supported by four samples of clean milk, three of which would come under the head of certified milk. The percentages of the various groups in these samples are shown in Table 16.

TABLE 16.—*Daily percentage of lactic acid and other bacteria in clean raw milk held at 10° C. (50° F.).*

Sample No.	Age of milk in days.	Acidity as percentage of lactic acid.	Total bacteria per c. c. on litmus lactose gelatin.	Peptonizing bacteria.	Lactic-acid bacteria.	Alkali or inert bacteria.
			Number.	*Per cent.*	*Per cent.*	*Per cent.*
341	0	0.19	4,400	34.09	13.63	52.27
	1	....	50,000	30.00	....	70.00
	2	.21	31,200,000	9.61	....	90.38
	3	.21	34,000,000	20.58	....	79.41
	4	.20	200,000,000	30.00	....	70.00
	5	....	140,000,000	31.42	....	62.85
	6	.28	....	....	....	....
	7	.50	410,000,000	36.58	17.07	46.34
342	0	.19	1,400	57.14	14.28	28.57
	1	.20	4,000	52.50	22.50	25.00
	2	.19	868,000	4.14	....	95.85
	3	....	36,700,000	8.71	....	91.28
	4	.27	81,000,000	6.17	....	93.82
	5	....	....	....	....	....
	6	.43	590,000,000	3.38	42.37	54.23
343	0	.19	67,000	43.28	5.97	50.74
	1	....	8,200,000	20.73	....	79.26
	2	.21	27,700,000	18.05	.72	81.22
	3	....	....	....	....	....
	4	.25	292,000,000	4.79	38.01	57.19
344	0	....	5,400	70.37	11.11	18.51
	1	.21	170,000	35.29	....	64.70
	2	....	....	....	....	....
	3	.24	122,000,000	11.47	.81	87.70

A discussion of this table is hardly necessary. The absence of bacteria of the acid group may be noticed in all cases, also the correspondingly high percentage of the other two groups.

THE BACTERIAL CONTENT OF PASTEURIZED AND RAW MILK.

Thus far the proportion of groups of bacteria in pasteurized and raw milk has been discussed. The bacterial numbers in both kinds of milk may now be considered.

INITIAL COUNTS OF BACTERIA.

In Table 17 the samples of pasteurized and raw milk are grouped into classes, the limits of which are purely arbitrary, based according to their counts. The bacterial numbers represent the initial count of bacteria per cubic centimeter in the various kinds of milk as the consumer received it. Comparison of pasteurized and raw milk in Boston shows that the bacterial numbers from dairies A and B were on the whole lower than those of raw milk from dairy G, although dairy G is one of the best dairies supplying raw milk to the city. The bacterial counts of the pasteurized milk from dairy C are given separately in order to show the high counts, which are quite significant. This milk was sold from cans in markets and bakeries and very little was bottled except for special trade. The samples were purchased from shops at various times in glass milk bottles which were clean although not sterile. Undoubtedly, however, the conditions under which the milk was purchased duplicated those under which the housewife would purchase the same milk. An examination of the machine at the plant showed the process to be quite efficient, and doubtless the high counts were due to infection from the milk cans and wooden stoppers or to long holding of the milk in the shops. Whichever was the cause, it appears evident that pasteurized milk should not be supplied in cans, especially where it is to be sold to the consumer from stores. It may be seen from the table that in the summer pasteurized milk from dairy A was much lower in bacterial numbers than the raw milk examined. As explained earlier in this paper, in all the milk the counts were high, due to the method of delivery in which the milk was exposed to high temperatures during the early morning hours. The pasteurized milk examined in New York showed very low counts—29 out of a total of 39 being below 20,000 per cubic centimeter. The majority of the samples of pasteurized milk were much lower in bacteria than the raw milk.

TABLE 17.—*Comparison of bacterial content of raw and pasteurized milk from various sources—The samples of each kind of milk arranged in classes according to their initial bacterial count.*

Class.	Bacteria per c. c.	Boston, winter.			Boston, summer.		New York, winter.	
		Pasteurized milk.		Raw milk from dairy G.	Pasteurized milk from dairy A.	Raw milk from stores and dairies E and F.	Pasteurized milk from dairies H, K, and M.	Raw milk from dairies P and N and stores.
		From dairies A and B.	From dairy C.					
		Samples.	*Samples.*	*Samples.*	*Samples.*	*Samples.*	*Samples.*	*Samples.*
A	0 to 20,000	7	1	1	3	0	29	0
B	20,000 to 50,000	16	1	2	3	0	5	3
C	50,000 to 100,000	8	1	4	0	0	3	2
D	100,000 to 500,000	15	0	12	5	0	2	10
E	500,000 to 1,000,000	1	0	3	1	0	0	1
F	1,000,000 to 10,000,000	0	17	2	0	13	0	1
G	10,000,000 to 50,000,000	2	2	0	0	5	0	1
H	50,000,000 or over	0	1	2	1	3	0	0
	Total number of samples	49	23	26	13	21	39	18

RATE OF INCREASE OF THE BACTERIA.

In a similar manner the various milks have been grouped according to their bacterial counts after holding twenty-four hours, the result of which is shown in Table 18. The pasteurized milk from dairies A and B in Boston was on the whole much lower than raw milk from dairy G. The same was true of pasteurized milk examined during the summer. The pasteurized milk from dairy C which was bought "loose" in stores showed a high count, corresponding, of course, to the initial high counts. In New York the pasteurized milk was strikingly low in bacteria even after twenty-four hours holding, which would be expected from the low initial counts. It is evident from these results that the pasteurized milk in both cities was of a very good quality. Of course this study did not include all the pasteurizing plants of the two cities, but it represents the three largest in each case.

Table 18.—*Comparison of rate of increase of bacteria in raw and pasteurized milk from various sources after holding for twenty-four hours at 10° C. (50° F.).*

Class.	Bacteria per c. c.	Boston, winter.			Boston, summer.		New York, winter.	
		Pasteurized milk.		Raw milk from dairy G.	Pasteurized milk from dairy A.	Raw milk from stores and dairies E and F.	Pasteurized milk from dairies H, K, and M.	Raw milk from dairies P and N and stores.
		From dairies A and B.	From dairy C.					
		Samples.	*Samples.*	*Samples.*	*Samples.*	*Samples.*	*Samples.*	*Samples.*
A	0 to 20,000	0	0	0	0	0	3	0
B	20,000 to 50,000	0	0	0	0	0	3	0
C	50,000 to 100,000	1	0	0	0	0	4	0
D	100,000 to 500,000	7	0	1	1	0	4	2
E	500,000 to 1,000,000	3	0	0	0	0	1	2
F	1,000,000 to 10,000,000	9	3	8	2	0	2	4
G	10,000,000 to 50,000,000	1	5	7	7	1	0	0
H	50,000,000 or over	1	8	6	1	16	0	1
	Total number of samples	22	16	22	11	17	17	9

The question of bacterial increase in pasteurized and raw milk is one which causes much discussion. The best authorities on the subject differ in their views, and any data that will tend to settle the question must necessarily be of value. The bacterial increase during the first twenty-four hours in a number of samples from the various sources used in this investigation has therefore been tabulated, the milk being held at 10° C. (50° F.). The details are given in Table 19, as follows:

Table 19.—*Ratio of increase of bacteria in pasteurized and raw milk after holding for twenty-four hours at 10° C. (50° F.).*

BOSTON, WINTER 1908-9—PASTEURIZED MILK FROM DAIRIES A AND B.

Sample No.	Bacteria per c. c.		Ratios.	Sample No.	Bacteria per c. c.		Ratios.
	0 days.	1 day.			0 days.	1 day.	
1	36,400	142,000	1:3.9	10	45,300	790,000	1:17.4
2	40,700	260,000	1:6.3	11	48,700	430,000	1:8.8
3	205,000	2,100,000	1:10.2	12	34,000	1,970,000	1:57.9
4	117,000	280,000	1:2.3	13	175,000	1,140,000	1:6.5
5	220,000	7,800,000	1:33.9	14	56,200	1,400,000	1:25.6
6	529,000	7,820,000	1:14.5	15	9,000	2,400,000	1:266.6
7	214,000	3,500,000	1:16.3	16	35,000	2,400,000	1:68.5
8	204,000	950,000	1:4.6				
9	116,000	18,700,000	1:161.2	Average ratio			1:44.03

TABLE 19.—*Ratio of increase of bacteria in pasteurized and raw milk after holding for twenty-four hours at 10° C. (50° F.)*—Continued.

Sample No.	Bacteria per c. c.		Ratios.	Sample No.	Bacteria per c. c.		Ratios.
	0 days.	1 day.			0 days.	1 day.	
BOSTON, WINTER 1908-9—PASTEURIZED MILK FROM DAIRY C.							
1	3,300,000	10,600,000	1:3.2	7	2,640,000	10,500,000	1:3.9
2	5,800,000	190,000,000	1:30.7	8	4,000,000	32,000,000	1:8.0
3	1,100,000	27,200,000	1:24.7	9	1,140,000	6,000,000	1:5.2
4	1,450,000	231,000,000	1:159.3	10	1,410,000	11,200,000	1:7.9
5	7,000,000	26,200,000	1:3.7				
6	1,750,000	8,800,000	1:5.0	Average ratio............			1:25.1
BOSTON, WINTER 1908-9—RAW MILK FROM DAIRY G.							
1	71,000	118,000	1:1.4	7	130,000	2,000,000	1:15.3
2	24,000	2,100,000	1:87.5	8	310,000	25,200,000	1:81.2
3	261,000	3,500,000	1:13.4	9	128,000	18,000,000	1:140.0
4	490,000	8,000,000	1:16.6				
5	39,000	3,900,000	1:100.0	Average ratio............			1:52.4
6	120,000	1,800,000	1:16.3				
BOSTON, SUMMER 1909—PASTEURIZED MILK FROM DAIRY A.							
1	450,000	2,740,000	1:6.1	5	95,000	22,300,000	1:233.7
2	97,000	56,200,000	1:579.3	6	286,000	90,000,000	1:314.6
3	784,000	44,000,000	1:56.1				
4	27,000	2,700,000	1:100.0	Average ratio............			1:214.9
BOSTON, SUMMER 1909—RAW MILK FROM DAIRIES E AND F AND STORES.							
1	2,570,000	95,000,000	1:36.9	9	4,500,000	79,000,000	1:17.5
2	13,900,000	85,000,000	1:6.11	10	1,900,000	18,500,000	1:9.73
3	5,000,000	238,000,000	1:47.6	11	3,400,000	80,000,000	1:23.5
4	9,700,000	164,000,000	1:16.9	12	5,700,000	200,000,000	1:35.0
5	28,200,000	505,000,000	1:17.9	13	11,200,000	177,000,000	1:15.8
6	43,100,000	200,000,000	1:4.64				
7	8,800,000	106,000,000	1:12.03	Average ratio............			1:19.5
8	11,400,000	124,000,000	1:10.8				
NEW YORK, WINTER 1909—PASTEURIZED MILK FROM DAIRY H.							
1	11,200	42,000	1:3.7	9	34,000	120,000	1:3.5
2	10,000	50,000	1:5.0	10	16,500	1,610,000	1:97.5
3	29,800	59,000	1:1.9	11	25,400	12,400,000	1:448.1
4	18,000	40,000	1:2.2	12	13,400	950,000	1:70.8
5	5,900	14,000	1:2.3	13	6,700	16,000	1:2.3
6	14,000	87,000	1:6.2				
7	26,000	1,170,000	1:45.0	Average ratio............			1:53.1
8	31,500	68,000	1:2.1				
WASHINGTON, WINTER 1910—RAW MILK FROM DAIRY T.							
1	85,000	30,800,000	1:362.3	9	172,000	7,000,000	1:40.6
2	43,400	660,000	1:15.2	10	464,000	1,100,000	1:2.3
3	30,000	400,000	1:13.3	11	243,000	3,810,000	1:15.6
4	149,000	260,000	1:1.74	12	146,000	1,030,000	1:48.1
5	126,000	17,900,000	1:142.0	13	36,000	3,700,000	1:102.7
6	125,000	9,500,000	1:76.0	14	78,000	3,210,000	1:41.1
7	523,000	8,900,000	1:17.0				
8	627,000	21,000,000	1:33.2	Average ratio............			1:65.07

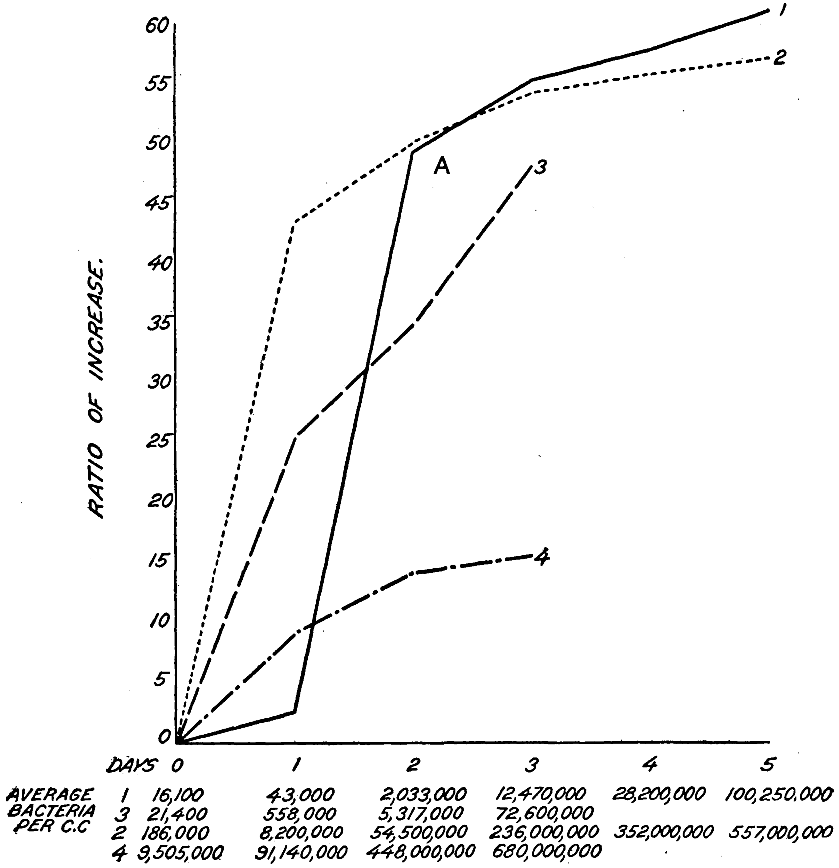
Taking first the Boston winter milk, the table shows the average ratio of bacterial increase in the series of pasteurized milk from dairies A and B to be 1 to 44.03; in raw milk from dairy G it is 1 to 52.40, and in pasteurized milk from dairy C it is 1 to 25.1. From these figures little difference is evident in the ratio of bacterial increase in pasteurized milk from dairies A and B and raw milk from dairy G. On the other hand, in pasteurized milk from dairy C the rate of increase was much lower. The question may be asked, Why not the same rate of increase in both series of pasteurized milk? The difference is easily explained if the first two sections of the table are compared. In the pasteurized milk from dairies A and B the initial counts of the samples were low as compared to those of dairy C. The ratio of increase in the first case was obtained during the rapid development of the bacterial numbers, while in the milk from dairy C the bacterial content was originally high, so that the period of active growth had passed and the initial counts were much nearer their ultimate point of increase. Rogers [18] has also suggested the fact that the period of rapid bacterial increase must be taken into consideration.

This point is shown more clearly in the fourth and fifth sections of the table, dealing with the Boston summer milk. It is here seen that in the pasteurized milk the average ratio is 1 to 214.9 as compared with 1 to 19.5 in the raw milk. Here again there were low initial numbers in the pasteurized milk and high ones in the raw milk. In this case it is true that the bacteria in the heated milk did increase faster than those in the raw milk, but it would not be correct to assume from these figures that bacteria increase faster in pasteurized milk in general. But suppose that the initial counts of the raw milk had been as low as the counts in the pasteurized milk, then the condition in both would be comparable, because in each case the ratios during the first twenty-four hours would cover the period of active increase. If under such conditions the same ratio of increase held as shown in the table, then it would be more reasonable to state that bacteria increase more rapidly in pasteurized than in raw milk.

This is well illustrated in the last two sections of the table. Here are shown the counts of the pasteurized milk from dairy H in New York and of the clean raw milk from dairy T in Washington. In both cases the initial counts were low and the ratios of bacterial increase were approximately the same. In both cases one or two twenty-four-hour high counts increased the average ratio, but on examination of the individual ratios it may be seen that in general the bacteria grew faster in the raw milk.

INACCURACY OF RATIOS OF INCREASE WHEN INITIAL COUNTS VARY TOO WIDELY.

In order to show how misleading ratios may be, and how it is impossible to compare ratios of increase in samples of milk in which the initial counts vary widely, four kinds of milk have been chosen and their daily ratios of increase compared, as shown in Table 20 below and in figure 16. The four milks used consisted of the two pasteurized kinds—one by the "holder" and one by the "flash" process—a clean raw milk and a dirty raw milk. The ratios in the table represent the increase on each successive day and not from the first to second, first to third, etc. Curve 1 in figure 16 represents the milk pasteurized by the "holder" process, curve 2 the clean raw milk, curve 3 the milk pasteurized by the "flash" process, and curve 4 the dirty raw milk. In all cases the milk was held at 10° C. (50° F.). The curves have been plotted by using the actual ratios,



AVERAGE BACTERIA PER C.C	DAYS 0	1	2	3	4	5
1	16,100	43,000	2,033,000	12,470,000	28,200,000	100,250.000
3	21,400	558,000	5,317,000	72,600,000		
2	186,000	8,200,000	54,500,000	236,000,000	352,000,000	557,000,000
4	9,505,000	91,140,000	448,000,000	680,000,000		

FIG. 16.—Comparison of the ratio of increase of bacteria in pasteurized and raw milk held for five days at 10° C. (50° F.). Average daily counts of bacteria and ratios of increase. *1*, pasteurized milk, "holder" process; *2*, clean raw milk; *3*, pasteurized milk, "flash" process; *4*, dirty raw milk.

the first point on the curve being the ratio of increase from the first to the second day; the second point was determined by adding the ratio of increase from the second to the third day to the ratio of increase from the first to the second day, and so on.

It may be seen from curve 1—"holder" process, pasteurized milk—that the ratio of increase was small during the first twenty-four hours, after which there was a rapid increase, then a small daily increase from that time on. The average bacterial counts in Table 20 show that this rapid increase on the second day took place when the bacterial count was low, 43,000 to 2,033,000, after which the increase was again slow. The same thing is shown in curve 2 with clean raw milk, except that the slow increase on the first day does not occur. In this case the rapid increase from 186,000 to 8,200,000 took place during the first twenty-four hours, then the increase was slow again. The "flash" process pasteurized milk as shown in curve 3 represents the same conditions. In curve 4, however, the ratios of increase rise slowly, no very sudden rise being seen in the curve. In this case the average initial count was 9,505,000, so that the period of rapid bacterial increase had passed and only a gradual, slow increase took place.

Table 20.—*Daily ratio of increase of bacteria in various kinds of raw and pasteurized milk.*

[The ratio is calculated in each case in comparison with the count of the preceding day.]

Days.	Pasteurized milk, "holder" process.		Clean raw milk.		Dirty raw milk.		Pasteurized milk, "flash" process.	
	Average bacterial count of 11 samples.	Ratio of increase.	Average bacterial count of 14 samples.	Ratio of increase.	Average bacterial count of 9 samples.	Ratio of increase.	Average bacterial count of 11 samples.	Ratio of increase.
0	16,100	....	186,000	....	9,505,000	....	21,400	....
1	43,000	1 to 2.7	8,200,000	1 to 44.1	91,140,000	1 to 9.6	558,000	1 to 26.1
2	2,033,000	1 to 47.3	54,500,000	1 to 6.6	448,000,000	1 to 4.9	5,317,000	1 to 9.5
3	12,470,000	1 to 6.1	236,000,000	1 to 4.3	680,800,000	1 to 1.5	72,600,000	1 to 13.7
4	28,200,000	1 to 2.3	352,000,000	1 to 1.5	....	....	....	....
5	100,250,000	1 to 3.6	557,000,000	1 to 1.6	....	....	....	....
6	310,000,000	1 to 3.1	....	....	....	....	....	....

It can easily be seen how misleading ratios of increase as between pasteurized and raw milk may appear. When a comparison is made of curves 1 and 4 in figure 16, it would seem that the bacteria increased much more rapidly in the pasteurized than in the raw milk. But in this case the comparison would be fairer if curve 1 was considered from the point marked A, on the second day. At this point it may be seen that the bacterial count of the pasteurized milk was 2,033,000, while the raw milk as shown in curve 4 initially contained 9,505,000 per cubic centimeter. Curve 1 from the point A is about the same as curve 4 from the "0" point. In other words, the ratios of increase were about the same when compared from the periods at which their bacterial numbers were more nearly equal.

On the other hand, when raw milk had a low initial count, as was the case with curve 2, then curves 1 and 2 represent the conditions more fairly, and the conclusion would follow that bacteria increase, approximately, the same in pasteurized as in raw milk.

It is evident that if the initial counts are disregarded when comparing the ratios of pasteurized and raw milk in figure 16, any one of three contradictory conclusions can be arrived at. First, curves 1 and 4 would show that bacteria increased much faster in pasteurized than in raw milk. Second, curves 2 and 3 would show that bacteria increased faster in the raw milk than in the pasteurized. Third, curves 1 and 2 would show that the bacteria increased approximately the same in both milks.

The data in figure 16 were not intended to show in which milk the bacteria do actually reproduce the fastest; it was the purpose merely to indicate how little value can be placed upon ratios alone. The results tend to prove that bacteria do increase approximately the same in pasteurized as in raw milk, provided their initial counts are practically alike. However, this point can only be definitely determined by a large number of experiments with pasteurized and raw milks in which the initial total count and group percentages are approximately the same.

LACTIC-ACID BACTERIA OF HIGH THERMAL DEATH POINT.

The pasteurized milk used in these experiments turned sour in every case, although the souring was delayed. This fact naturally suggests the question as to how lactic-acid bacteria survive pasteurization, or how they gain entrance to the milk after the process.

It is a generally accepted idea that pasteurization destroys the lactic-acid bacteria. Farrington and Russell[4] state that numerous experiments show the thermal death point of the lactic-acid bacteria to be in the neighborhood of 57.2° to 60° C. (135° to 140° F.) where the exposure was for ten minutes. It is not necessary to review here the numerous references to experiments showing the low resistance of the lactic-acid bacteria to heat, but it may be stated that the temperatures used in commercial pasteurization are always higher than the generally accepted thermal death point. On the other hand, here and there in the literature are references which indicate that there may be resistant strains of lactic-acid bacteria. Rogers[18] found that in milk pasteurized at 85° C. (185° F.) by the "flash" process and held at 20° C. (68° F.) lactic-acid bacteria occasionally survived which, after twenty-four hours, completely inhibited the peptonizing bacteria.

Marshall[14] states:

> It is largely supposed that in pasteurized milk the lactic-acid bacteria are killed. This is largely true but not universally. Sometimes the milk is curdled by acid formation without any digestion as in the usual lactic-acid fermentation.

Wolff[25] found living Güntheri organisms in milk pasteurized at 70° C. (158° F.) for one-half hour, but this occurred only when at the time of heating there had been a definite amount of acid formation, which he believed caused a coagulation in the form of a protecting envelope about the organisms, so that they were not only able to resist the pasteurizing temperature themselves, but could carry other organisms through with them.

Several other nonspore-forming organisms besides lactic-acid bacteria have been mentioned as resisting high temperatures.

Russell and Hastings[20] describe an organism capable of standing 76° C. (168.8° F.) for ten minutes. De Jong and de Graff,[10] working on various strains of *Bacillus coli* found some forms which required thirty minutes heating at 70° to 72° C. (158° to 161.6° F.) to destroy. Zelenski[26] also found some strains of *B. coli*, which resisted high temperatures, and showed that higher temperatures were required to kill the organism in milk than in broth. He suggested that the proteids or, perhaps, the presence of fat in milk formed a protecting envelope for the bacteria.

EXPERIMENTS TO DETERMINE THERMAL DEATH POINT.

In order to determine if the lactic-acid bacteria in milk are capable of resisting high temperatures, a number of experiments were made by heating milk in Sternberg bulbs. The results of some of these experiments are tabulated in Table 21 below:

TABLE 21.—*The thermal death point of lactic-acid bacteria—Results of heating milk at various temperatures in Sternberg bulbs for thirty minutes.*

[+=Positive result, indicated by typical solid curd.]

Temperature.	Experiment I, whole milk.	Experiment II.		Experiment III, whole milk.	Experiment IV, whole milk.	Experiment V.
		Whole milk.	Skim milk.			
60° C. (140° F.)	+ +	+ +	+ +	....	+ + + +	+ +
62.8° C. (145° F.)	+ +	+ +	+ +	....	....	....
65.6° C. (150° F.)	+ +	+ +	+ +	....	+ + + +	+ + .
68.3° C. (155° F.)	+ +	+ +	+ +	....	....	....
71.1° C. (160° F.)	+ + gas.	+ +	+ +	+	+ + + +[a]	+ +
73.9° C. (165° F.)	....	....	....	Partly digested acid curd.	Acid, coagulated, slightly peptonized.[b]	....
76.7° C. (170° F.)	....	....	....	Partly digested slightly acid curd.	+ + + + Decolorized curd, three-fourths peptonized.[c]	....

[a] The milk cultures on plating showed a large number of lactic-acid bacteria.

[b] The milk cultures on plating showed numerous lactic-acid bacteria.

[c] The milk cultures on plating showed no lactic-acid bacteria.

After heating the milk in the bulb it was introduced into tubes of sterile litmus milk. If the milk tubes showed typical solid curd decolorized except for the top acid ring, then the result was regarded as positive and is indicated in the table by the plus sign. As the table shows, all the milk tubes gave positive reactions when the bulbs were heated for thirty minutes at 71.1° C. (160° F.) and below, both in whole and skim milk. At 73.9° C. (165° F.) some of the tubes showed signs of peptonization. The milk in bulbs heated at 76.7° C. (170° F.) upon incubation in milk did not give the normal acid curd but either a slight acid or rennet curd with considerable digestion. A number of milk tubes inoculated from milk in bulbs heated to 71.1° C. (160° F.) were plated and showed the presence of a large number of colonies typical of the lactic-acid bacteria when plated on plus 1.5 litmus lactose agar and incubated at 37° C. (98.6° F.). Those heated to 73.9° C. (165° F.) showed numerous lactic-acid bacteria, while plates from milk inoculated from bulbs heated to 76.7° C. (170° F.) showed no lactic-acid colonies.

The results of these experiments correspond to those of numerous others in which milk was heated in cans and held at the same temperatures. It was observed in most cases that milk heated for thirty minutes at 71.1° C. (160° F.) and below gave a normal acid curd, while that heated at higher temperatures showed slight acid or even rennet curds with considerable digestion.

Besides heating the milk in bulbs for thirty minutes some was also heated for two minutes, which may serve to approximate the "flash" process. These results are shown in Table 22. It may be seen that with a short heating the lactic-acid bacteria may resist higher temperatures than when heated for thirty minutes.

TABLE 22.—*The thermal death point of lactic-acid bacteria—Results of heating milk at various temperatures in Sternberg bulbs for two minutes.*

[+ = Positive result, indicated by typical solid curd.]

73.9° C. (165° F.).	76.7° C. (170° F.).	79.4° C. (175° F.).	82.2° C. (180° F.).
Acid, coagulated, slight whey. + + + + +	Same as 165° F. + + + + +	[a] Acid, coagulated, partly peptonized. + + + + +	[b] Partly peptonized, slightly acid. + + + + +

[a] On plating out the coagulated milks, seven cultures picked off out of a total of ten gave the typical reaction of lactic-acid bacteria in milk.

[b] Seven cultures picked off plates made from the milk cultures turned milk acid, but did not coagulate it after seventy-two hours.

It must be noted that the milks used in these experiments contained large numbers of lactic-acid bacteria, the counts generally being high, due to hot weather.

From the heating experiments approximately 45 cultures of lactic-acid bacteria were isolated, all of which proved upon cultural tests to be typical of the streptococcus lacticus type of lactic-acid organism.

Numerous thermal death-point determinations showed that the death point of many of the lactic-acid organisms varied; the limit of resistance of some was between 65.6° C. (150° F.) and 71.1° C. (160° F.), while others stood thirty minutes heating in bulbs at temperatures above 71.1° C. (160° F.). One culture (will be called culture A) was selected as one of the organisms resisting the highest temperatures. It is typical of the streptococcus lacticus type in its cultural characteristics. Determinations of its thermal death point in milk were made every 2° F. upward from 58.9° C. (138° F.). In all cases the heating was carried on in Sternberg bulbs for thirty minutes. The death point was set at the first temperature above the temperature at which both control tubes showed growth within seventy-two hours.

Determinations made in milk, two sets in September, two in November, and two in December, showed the thermal death point to be 75.6° C. (168° F.). The interval between the determinations shows that the high resistance is a permanent character and not a temporary freak of the organism. The thermal death point of culture A in broth was 74.4° C. (166° F.), using the same period of heating. Experiments were tried, using 18 per cent and 20 per cent cream, but no increase in the thermal death point was observed. The thermal death point with a ten-minute exposure was found to be 77.8° C. (172° F.).

The effect of temperature on the bacterial numbers of culture A is shown in Table 23.

TABLE 23.—*The thermal death point of lactic-acid bacteria—Effect of heating on the numbers of lactic organisms in culture A—Milk heated in small flasks submerged to the neck in water bottle for thirty minutes—Temperature readings taken directly in the milk.*

Temperature.	Bacteria per c. c. before heating.	Bacteria per c. c. after heating for 30 minutes.	Reduction.
			Per cent.
60° C. (140° F.)..	58,000,000 64,500,000	63,000,000 51,000,000	0
	[a] 61,250,000	57,250,000	
65.6° C. (150° F.)..	41,000,000	41,700,000	0
71.1° C. (160° F.)..	244,000,000 315,000,000	133,000,000 138,000,000	53.07
	[a] 284,500,000	135,500,000	

[a] Average.

Thirty minutes heating at 60° C. (140° F.) or 65.6° C. (150° F.) had no reducing effect, while at 71.1° C. (160° F.) the percentage reduction was only 53.07 per cent.

Even the "majority" thermal death point of culture A as suggested by Gage and Stoughton [8] would be very high as compared with the ordinary nonspore-forming bacteria. It is evident that these high-temperature-resisting organisms are different strains of the common lactic-acid bacteria and that they play an important part in pasteurized milk. These organisms, together with other species of nonspore-forming bacteria of high thermal death point which we have isolated, will be the subject of further investigation.

In connection with the determination of the thermal death point of bacteria it should be mentioned that it is necessary to keep the acidity of the media down as low as possible at the time of heating when the organism is grown in milk or broth. It was found that the thermal death point of culture A was lowered a number of degrees by using a culture of sugar broth of such an age that the acidity was high. In some unpublished work by Davis of this laboratory it was found that as the acidity increased the thermal death point decreased.

PER CENT OF LACTIC-ACID BACTERIA CAPABLE OF WITHSTANDING HIGH TEMPERATURES.

A number of experiments have been made to determine the approximate percentage of lactic-acid bacteria which were capable of standing high temperatures. Raw milk was heated in flasks in the laboratory for thirty minutes at 60° C. (140° F.) and 65.6° C. (150° F.) and then plated on litmus lactose agar reaction plus 1.5 and incubated at 37° C. (98.6° F.) for forty-eight hours. The results are shown in Table 24.

TABLE 24.—*Showing percentage of lactic-acid bacteria of high thermal death point in milk.*

No.	Kind of milk.	Pasteurized in laboratory in flasks for 30 minutes at—	Total bacteria per c. c.	Acid bacteria per c. c.	Percentage of acid colonies.	Percentage of reduction of acid colonies.	Remarks.
1	Raw	....	146,000	20,000	13.6	....	
		65.6° C. (150° F.).	1,080	480	44.4	97.6	
2	do	....	620,000	100,000	16.1	....	
		60° C. (140° F.)	470	70	14.8	99.93	
		65.6° C. (150° F.).	280	40	14.2	99.96	
3	do	....	4,520,000	3,930,000	86.9	....	Milk was held in refrigerator for 24 hours before heating.
		60° C. (140° F.)	66,000	12,000	18.1	99.69	
		65.6° C. (150° F.).	3,300	1,400	42.4	99.94	
4	do	....	122,000	48,000	39.3	....	
		60° C. (140° F.)	9,000	4,900	54.4	89.79	
		65.6° C. (150° F.).	420	40	9.5	99.91	
5	Pasteurized	....	335,000	136,000	40.5	....	Pasteurized milk treated same as raw milk.
		60° C. (140° F.)	23,800	8,700	36.5	93.60	
		65.6° C. (150° F.).	9,200	0	0	100.00	
6	Raw	....	720,000	215,000	29.8	....	
		60° C. (140° F.)	2,100	900	42.8	99.58	
		65.6° C. (150° F.).	70	10	14.28	99.99	
7	do	....	31,500	6,400	20.3	....	
		60° C. (140° F.)	5,270	1,210	22.9	81.09	
		65.6° C. (150° F.).	5,120	130	2.5	97.96	
8	do	....	490,000	165,000	33.6	....	
		60° C. (140° F.)	50,600	1,270	2.50	99.23	
		65.6° C. (150° F.).	1,700	280	16.4	99.83	
9	do	....	90,000	8,000	8.8	....	
		60° C. (140° F.)	5,700	250	4.3	96.87	
		65.6° C. (150° F.).	4,700	250	5.3	96.87	
10	do	....	24,900	4,600	18.4	....	
		60° C. (140° F.)	3,020	600	21.85	85.65	
		65.6° C. (150° F.).	1,710	10	.58	99.78	
11	do	....	102,000,000	65,000,000	63.7	....	Milk held 3 days at 10° C. (50° F.) before heating.
		60° C. (140° F.)	2,050	1,580	77.0	99.999	
		65.6° C. (150° F.).	490	440	89.7	99.999	
12	do	....	1,560,000	740,000	47.4	....	
		60° C. (140° F.)	460	320	69.5	99.95	
		65.6° C. (150° F.).	110	80	72.7	99.98	

In making the acid count only those colonies were included which were typical of the lactic-acid bacteria; that is to say, small acid colonies. It was found, however, that the count included a few colonies that were not true lactic forms, but were cocci which may belong to the group of organisms coming from the udder of the cow. This point is to be the object of further study. Sample 5 was a pasteurized milk, but even in that case after heating again at 60° C. (140° F.) 36.5 per cent of the total bacteria left were acid formers. In samples 11 and 12, where the initial count was very high, the per cent of acid colonies after heating to 60° C. (140° F.) and 65.6° C. (150° F.) was 69.5 and 72.7 per cent, respectively, of the total bacteria. Where the initial count was lower the percentage of acid colonies in the heated milk was correspondingly low. The percentage remaining in the milks varies considerably, as may be seen from the table, but if the percentages are averaged it will be found that the acid formers constituted 34.4 per cent of the total in raw milk; in the milk heated for thirty minutes at 60° C. (140° F.) the percentage was 32.8, and when heated at 65.6° C. (150° F.) it was 28.4 per cent of the total bacteria.

It is apparent that on the average the proportion of acid bacteria does not change very much when milk is heated at the temperatures used in these experiments. It might be expected in view of these facts that the pasteurized milk should sour as normally as does the raw milk, but the souring was delayed, due to the small numbers of the acid bacteria of high thermal death point and to their relatively slow growth.

In the last column of Table 24 are shown the percentages of acid bacteria destroyed during heating. The remainder represents the heat-resisting forms. At 60° C. (140° F.) the range in the various samples is from 0.001 to 18.91 per cent, and the average number of heat-resisting lactic organisms is 4.8 per cent. At 65.6° C. (150° F.) the range is from 0.001 to 3.13 per cent, with an average of 0.74 per cent. These figures are of course only approximate, but serve to show that about 4.8 per cent of the lactic-acid bacteria were able to stand heating to 60° C. (140° F.), while approximately 0.74 per cent were not destroyed at 65.6° C. (150° F.) for thirty minutes.

These results suggest that heat-resisting strains may occur in pathogenic bacteria as they do among the lactic-acid bacteria. The thermal death points of pathogenic bacteria have been determined in but few instances, as has been the case with the lactic-acid forms. That of the typhoid bacillus might, for example, be determined if urine from a number of typhoid patients were heated in bulbs, as was for the milk in these experiments. It might thus be possible to isolate strains of the typhoid bacillus having a high thermal death point. However, the possibility of such strains existing does not in any way detract from the value of pasteurization as a protection against pathogenic bacteria, for the reason that only a very few pathogenic organisms are ever present in milk and the possibility of heat-resisting strains in that small number is infinitely small, because if such exist they form only a minute percentage of the total. This point is mentioned merely as a suggestion for those interested in the study of pathogenic bacteria.

SUMMARY AND CONCLUSIONS.

The results in this paper hold only for commercially pasteurized milk. By commercial pasteurization is meant milk heated from 60° C. (140° F.) to 65.6° C. (150° F.) in the "holder" process, or up to 71.1° C. (160° F.) in the "flash" process. At the present time the tendency is to use low temperatures with the "holder" process, and in commercial work it is doubtful if temperatures will ever be used universally in either process higher than those above mentioned. When higher temperatures are used the cream line is liable to be destroyed, a cooked taste may be produced which injures the sale of the milk, and the cost of pasteurization is increased by the use of more steam. It is not reasonable, therefore, to expect the use of high temperatures in commercial pasteurization. Arbitrary limits could be set, as 60° C. (140° F.) to 62.8° C. (145° F.) and even perhaps to 65.6° C. (150° F.) for the "holder" process and 71.1° C. (160° F.) to 73.9° C. (165° F.) for the "flash" process, at which temperatures milk when heated under commercial conditions may be expected eventually to sour, and the bacterial content will be comparable to the average group curves for pasteurized milk as shown in this paper. If higher temperatures are used a degree of heat may be reached which will result in the destruction of all but spores, which, when allowed to develop, will undoubtedly produce peptonization of the milk. Granting that 60° C. (140° F.) for twenty minutes is sufficient to destroy pathogenic organisms, it is believed it would nevertheless be advisable in commercial work to use a temperature a little higher, as 62.8° C. (145° F.) and for thirty minutes. That temperature would be sufficiently high to afford protection against pathogenic bacteria and yet would probably leave in the milk the maximum proportion of lactic-acid bacteria, and the group proportions would be very similar to those of all grades of market milk.

CONCLUSIONS.

1. Commercially pasteurized milk always sours, because of the development of lactic-acid bacteria which on account of their high thermal death point survive pasteurization, and perhaps in some cases because of subsequent infection with acid-forming bacteria during cooling and bottling.

The acid development in an efficiently pasteurized milk is about the same as that in a clean raw milk. But sometimes a strong, old taste develops which is probably due to the development of alkali or inert bacteria. The old taste, however, is not characteristic of pasteurized milk, for it may be noticed as well in clean raw milk when held under similar conditions. The less efficient the pasteurizing process the more closely does the acid increase of the heated milk approach that of a dirty raw milk.

2. The relative proportion of the groups of peptonizing, lactic acid, and alkali or inert bacteria is approximately the same in efficiently pasteurized milk as it is in clean raw milk. In both cases the alkali or inert forms constitute the largest group, the lactic-acid bacteria next, while the peptonizers are in the minority. When both of these milks—the efficiently pasteurized and clean raw milk—are held, the group relations change; but if the changes which take place are compared it will be found that they are the same in each. At the time of souring, the group proportions have changed so that the lactic-acid bacteria constitute the largest group with the alkali or inert forms next in order and the peptonizers in the smallest proportion as initially. In both of these milks the group of peptonizers may increase slightly in its proportion to the other two groups during the first two days, but it then gradually decreases and always forms the smallest group.

When milk is less efficiently pasteurized the position of the groups may be reversed so that the lactic-acid bacteria constitute the largest group with the alkali or inert forms next in order, but here again the peptonizers form the smallest proportion of the total bacteria. This group arrangement is the same in a dirty raw milk.

The more efficient the pasteurization, the smaller the percentage of lactic-acid bacteria; and, similarly, the cleaner the raw milk, the smaller the percentage of lactic-acid bacteria.

3. The peptonizing bacteria are present in smaller numbers in the inferior grades of commercially pasteurized milk during the first twenty-four hours after receiving than in raw milk of the same quality, and the peptonizers may increase to slightly higher numbers in the pasteurized milk when held several days than in the raw milk of high initial lactic-acid bacteria content; but it should be remembered in this connection that milk is usually consumed within twenty-four hours after delivery. The number of peptonizers in a good grade of commercial pasteurized milk on the initial count and on succeeding days is approximately the same as in a clean raw milk when held under similar temperature conditions.

4. Lactic-acid bacteria of high thermal death point are found in milk and may be easily isolated by special methods of procedure. From these experiments it was found that when milk is heated for

thirty minutes at 60° C. (140° F.) and plated, the percentage of acid-forming organisms that resisted the heating ranged from 0.001, to 18.91, the average being 4.8 per cent of the total acid colonies. When heated at 65.6° C. (150° F.) the range is from 0.001 to 3.13 per cent, the average being 0.74 per cent of the total bacteria. It must be remembered that these figures are based upon acid colonies, and these are not necessarily all true lactic-acid bacteria.

The thermal death point of one lactic-acid organism which was isolated from milk is 74.4° C. (166° F.) in broth and 75.6° C. (168° F.) in milk when heated in Sternberg bulbs for thirty minutes. When heated for ten minutes in milk the thermal death point is 77.8° C. (172° F.).

These heat-resisting lactic-acid bacteria play an important part in pasteurized milk and undoubtedly account to a large extent for its ultimate souring.

5. All milk, whether pasteurized or raw, must necessarily be infected during cooling and bottling by bacteria in the receiving tanks, in the pipes, on the cooler, and in the bottles; but the low bacterial counts obtained from pasteurized milk in these investigations show that the reinfection must have been very small.

6. It is manifestly unfair to conclude that bacteria increase faster in pasteurized than in raw milk, simply from a comparison of the ratios of bacterial increase. If a pasteurized milk with a low initial count is compared with a raw milk of high bacterial content then the ratios of increase may show that the bacteria in the heated milk do increase faster; but if the same pasteurized milk is compared with a clean raw milk with a low count, then the ratios of increase will be found to be approximately the same. From the results of this investigation it is evident that bacterial increase in an efficiently pasteurized and a clean raw milk is about the same when the samples of milk are held under similar temperature conditions. This question of the relative growth of bacteria in raw and pasteurized milk can be properly settled only by a long series of comparisons of samples of milk with approximately the same bacterial count and similar bacterial group percentages.

7. The ''holder'' process of pasteurization is superior to the ''flash'' process. With the ''holder'' process a high efficiency may be obtained with a low temperature, while to obtain the same efficiency with the ''flash'' process a high temperature would be required. A temperature of 62.8° C. (145° F.) for thirty minutes seems best adapted for efficient pasteurization.

8. Considering the low counts of bottled commercially pasteurized milk and the similarity of the bacterial group proportions to those of clean raw milk, the former can not be classed from a bacteriological point of view as inferior to commercial raw milk. Pasteurized and

raw milk should, however, always be bottled and should not be allowed to be sold as "loose" milk from stores.

9. Pasteurization should always be under the control of competent men who understand the scientific side of the problem. It is believed that ignorance of fundamental bacteriological facts often accounts for inefficient results rather than a willful lack of care on the part of the dairyman.

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In conclusion, it is desired to acknowledge the kindness of officials of the boards of health in Boston and New York in furnishing information regarding the milk supply, and to express our thanks to the officials of various milk companies who have allowed milk samples to be taken at their plants.

REFERENCES TO LITERATURE.

1. ALBERT, HENRY. Typhoid bacilli carriers. Abstract of an address read before the American Public Health Association, Winnipeg, August, 1908. American Journal of Public Hygiene, vol. 19, No. 2 (n. s., vol. 5, No. 2), pp. 260–267. Boston, May, 1909.
2. AMERICAN PUBLIC HEALTH ASSOCIATION. Report of committee on standard methods of water analysis to the laboratory section. Journal of Infectious Diseases, Supplement No. 1, pp. 1–141. Chicago, May, 1905.
3. ANDERSON, JOHN F. The frequency of tubercle bacilli in the market milk of the city of Washington, D. C. U. S. Treasury Department, Public Health and Marine-Hospital Service, Hygienic Laboratory, Bulletin 41, pp. 163–192. Washington, 1908.
4. FARRINGTON, EDWARD H., and RUSSELL, HARRY L. Pasteurization of milk and cream at 140° F. Wisconsin Agricultural Experiment Station, Sixteenth Annual Report, pp. 129–139. Madison, 1899.
5. FLÜGGE, CARL G. F. W. Die Aufgaben und Leistungen der Milchsterilisirung gegenüber den Darmkrankheiten der Säuglinge. Zeitschrift für Hygiene, Band 17, pp. 272–340. Leipzig, 1894. Abstract Centralblatt für Bakteriologie, Abt. 1, Band 17, No. 9–10, pp. 326–330, Jena, Mar. 15, 1895.
6. FREEMAN, ROWLAND G. Pasteurization of milk. Journal American Medical Association, vol. 54, No. 5, pp. 372–373. Chicago, Jan. 29, 1910.
7. FREUDENREICH, EDWARD DE. Sur la pasteurisation du lait dans l'alimentation de l'enfance. Revue Générale du Lait, ann. 4, No. 19, pp. 433–437. Lierre, July 15, 1904.
8. GAGE, STEPHEN DE M., and STOUGHTON, GRACE VAN EVEREN. A study of the laws governing the resistance of *Bacillus coli* to heat. Technology Quarterly, vol. 19, No. 1, pp. 41–54. Boston, Mar., 1906.
9. JENSEN, ORLA. De l'action du chauffage sur le lait de vache. Revue Générale du Lait, vol. 4, No. 16, pp. 361–368, May 30; No. 17, pp. 388–397, June 15; No. 18, pp. 419–424, June 30. Lierre, 1905.
10. JONG, DIRK A. DE, and GRAAFF, W. C. DE. Die Coli-Kontrolle der pasteurisierten Milch. [Nederlandsch Weekblad voor Zuivelbereiding en Veeteelt, vol. 12, Nos. 37 and 38, 1906.] Abstract Milchwirtschaftliches Zentralblatt, Jahrg. 3, Heft 6, pp. 265–268. Leipzig, June, 1907.
11. KENWOOD, HENRY. The pasteurization of milk. Journal Royal Sanitary Institute, vol. 29, No. 6, pp. 260–273. London, July, 1908.
12. LEDERLE, ERNST J. Pasteurization of milk. American Journal of Public Hygiene, vol. 17, No. 2 (n. s., vol. 3, No. 3), pp. 164–181. Boston, May, 1907.
13. LUMSDEN, LESLIE L. The milk supply of cities in relation to the epidemiology of typhoid fever. U. S. Treasury Department, Public Health and Marine-Hospital Service, Hygienic Laboratory, Bulletin 41, pp. 151–159. Washington, 1908.
14. MARSHALL, CHARLES E. Pasteurization of milk. Michigan Agricultural Experiment Station, Bulletin 147. Agricultural College, Aug., 1897.
15. PARK, WILLIAM H. Pathogenic micro-organisms, including bacteria and protozoa. New York and Philadelphia, 1900.

16. Pennington, Mary E., and McClintock, J. A. A preliminary report on the pasteurized and clean milk of Philadelphia. American Journal of Medical Sciences, n. s., vol. 130, No. 1, pp. 140–149. Philadelphia, July, 1905.

17. Rickards, Burt R. On the commercial pasteurization of milk. Abstract of an address read before the American Public Health Association, Winnipeg, August, 1908. American Journal of Public Hygiene, vol. 19, No. 3 (n. s., vol. 3, No. 3), pp. 507–513. Boston, Aug., 1909.

18. Rogers, Lore A. The bacteria of pasteurized and unpasteurized milk under laboratory conditions. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 73. Washington, 1905.

19. Rotch, Thomas M. The pasteurization of milk for public sale. American Journal of Public Hygiene, vol. 17, No. 2 (n. s., vol. 3, No. 3), pp. 181–211. Boston, May, 1907.

20. Russell, Harry L., and Hastings, Edwin G. A micrococcus, the thermal death limit of which is 76° C. Centralblatt für Bakteriologie, Abt. 2, Band 8, No. 11, pp. 339–342. Jena, Mar. 13, 1902.

21. Russell, Harry L., and Hastings, Edwin G. Agricultural bacteriology. Madison, Wis., 1909.

22. St. John, E. Q., and Pennington, Mary E. The relative rate of growth of milk bacteria in raw and pasteurized clean milk. Journal of Infectious Diseases, vol. 4, No. 4, pp. 647–656. Chicago, Nov. 15, 1907.

23. Schüder, ——. Zur Aetiologie des Typhus. Zeitschrift für Hygiene, Band 38, No. 3, pp. 343–354. Leipzig, Nov. 22, 1901.

24. Weber, A. Die Bakterien der sogenannten sterilisierten Milch des Handels, ihre biologischen Eigenschaften und ihre Beziehungen zu den Magen-Darmkrankheiten der Säuglinge, mit besonderer Berücksichtigung der giftigen peptonisirenden Bakterien Flügge's. Arbeiten aus dem Kaiserlichen Gesundheitsamte, vol. 17, No. 1, pp. 108–155. Berlin, 1900. Editorial. British Medical Journal, No. 2090, p. 170. London, Jan. 19, 1901.

25. Wolff, Arthur. Zur Kenntnis der Veränderungen in der Bakterienflora der frischen Milch während des sogenannten Inkubationsstadiums. Centralblatt für Bakteriologie, Abt. 2, Band 20, No. 18–20, pp. 545–563, Mar. 14; No. 21–23, pp. 651–675, Apr. 3; No. 24–25, pp. 737–780, Apr. 15. Jena, 1908.

26. Zelenski, Thaddaeus. Zur Frage der Pasteurisation der Säuglingsmilch. Jahrbuch für Kinderheilkunde, Jahrg. 63, pp. 288–307. Berlin, 1906. Abstract Centralblatt für Bakteriologie, Abt. 2, Band 18, No. 4–6, p. 175. Jena, Mar. 14, 1907.

APPENDIX.

COMMERCIAL MILK.

In the succeeding tables "0" days means the day the milk was received at the laboratory, which is equivalent to the time the consumer would receive it.

Table I.—*Acidity and bacterial content of commercially pasteurized milk in a small city—Milk held at 10° C. (50° F.).*

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.
27	0	0.13	20,250,000	800,000	10,700,000	2,200,000
	1	.18	80,960,000	1,300,000	51,200,000	....
	2	.25	....	....	....	....
29	0	.14	1,212,000	140,000	730,000	....
	1	.15	13,500,000	2,000,000	11,700,000	600,000
	2	.19	....	....	....	....
31	0	.17	6,310,000	310,000	6,200,000	2,200,000
	1	.17	42,500,000	1,200,000	19,700,000	16,300,000
	2	.24	....	....	....	....
33	0	.16	14,830,000	400,000	12,600,000	700,000
	1	.19	98,000,000	800,000	71,300,000	....
	2	.40	....	....	....	....
35	0	.14	240,000	10,000	63,000	37,000
	1	.16	715,000	900,000	200,000	[a] 200,000
	2	.17	....	....	....	....
37	0	.14	35,200	1,200	[b] 29,000	....
	1	.16	76,500	3,000	[b] 96,000	....
39	0	.14	25,000	....	....	....
	1	.16	68,650	....	....	....
41	0	.16	980,000	....	....	....
	1	.16	....	....	....	....
43	0	.17	33,350	....	....	....
	1	.17	45,400	....	....	....

[a] Dilution on gelatin plates was too high; differential count is of no value.

[b] Might have been alkali formers or inert forms.

TABLE II.—*Acidity and bacterial content of commercially pasteurized milk in a small city—Milk held at room temperature 22–25° C. (71.6–77° F.).*

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
28	0	0.17	21,500,000	700,000	5,600,000	2,700,000	A large proportion of these may have been of the Lactis aerogenes type.
	1	.78	1,861,000,000	2,000,000	1,180,000,000	....	Curdled; gas in curd.
30	0	.14	3,820,000	800,000	2,700,000	220,000	
	1	.78	1,774,000,000	1,000,000	[a] 1,600,000,000	....	Do.
32	0	.17	38,030,000	500,000	25,600,000	2,400,000	A large proportion may have been Lactis aerogenes.
	1	.90	390,000,000	....	[b] 346,000,000	....	Do.
34	0	.17	6,155,000	1,000,000	4,600,000	2,500,000	A large proportion may have been Lactis aerogenes; sour, curdled.
	1	.62	1,024,000,000	5,000,000	998,000,000	8,000,000	
36	0	.15	154,000	17,500	70,000	57,000	
	1	.57	1,364,000,000	25,000,000	[c] 1,040,000,000	....	Not curdled, but sour.
38	0	.14	34,250	1,500	2,500	(30,500) 2,600	May have been lactic-acid bacteria.
	1	.67	1,304,000,000	....	[d] 1,000,000,000	....	Curdled; gas in curd.
40	0	.15	24,700	100	....	6,700	
	1	.19	108,600,000	(e)	[f] 98,800,000	....	Counts from agar plates; temperature of room low probably accounts for slow acid formation.

[a] 29,000,000 Lactis aerogenes.
[b] 36,000,000 Lactis aerogenes.
[c] On agar.
[d] 1,000,000 Lactis aerogenes.
[e] Gelatin plate lost.
[f] 9,800,000 Lactis aerogenes.

TABLE III.—*Pasteurized milk in a small city—Total count and percentage of different groups—Milk held at 10° C. (50° F.).*

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
27	0	13,700,000	5.83	78.10	16.05
	1	52,500,000	2.47	97.52	....
29	0	870,000	16.09	83.90	....
	1	14,300,000	13.98	81.81	4.19
31	0	8,610,000	2.43	72.00	25.55
	1	37,200,000	3.22	52.95	43.81
33	0	13,700,000	2.91	91.97	5.10
	1	72,100,000	1.08	98.89	....
35	0	110,000	9.09	57.27	33.63
	1	....	....	....	....
37	0	30,200	3.97	96.02	....

Table IV.—*Pasteurized milk in a small city—Total count and percentage of different groups—Milk held at room temperature 22° to 25° C. (71.6° to 77° F.).*

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
28	0	9,000,000	7.77	62.22	30.00
	1	1,182,000,000	1.69	99.83	....
30	0	3,720,000	21.50	72.58	5.91
	1	1,630,000,000	.061	99.93	....
32	0	28,500,000	1.754	89.82	8.42
34	0	8,100,000	12.34	56.79	30.86
	1	1,011,000,000	.49	98.71	.79
36	0	144,500	12.11	48.44	39.44
	1	1,065,000,000	2.34	97.65	....
38	0	37,100	4.04	6.73	89.21

Table V.—*Raw and pasteurized milk at Boston, Mass., examined during November and December, 1908, and January, 1909—Milk held at 10° C. (50° F.).*

PASTEURIZED MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per. c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
45	0	....	22,800	4,900	22,400	9,100	Samples 45 to 63, inclusive, from dairy B, pasteurized 140°-150° F. (68°-65.6° C.), "flash" process.
	1	0.18	137,000	12,000	81,000 L. A.[a] 6,000	43,000	
47	0	.18	29,000	4,800	13,200	8,300	Large number of acid colonies on agar.
	1	.18	393,000	....	L. A. 2,000		
49	0	.19	39,500	3,400	33,600	3,700	
	1	.20	360,000	30,000	124,000 L. A. 6,000	100,000	
51	0	.20	200,000	7,000	57,000 L. A. 71,000	70,000	
	1	.21	2,000,000	100,000	800,000 L. A. 600,000	600,000	
53	0	.18	106,000	6,000	88,000	30,000	
	1						
55	0	.24	[b] 117,000	12,000	65,000	40,000	
	1	.27	360,000	150,000	10,000 L. A. 50,000	70,000	
57	0	.28	120,000	10,000	140,000 L. A. 40,000	30,000	
	1	.33	2,700,000	500,000	4,300,000 L. A. 400,000	2,600,000	
59	0	....	586,000	45,000	414,000	70,000	
	1	.19	7,620,000	330,000	7,040,000	450,000	
61	0	.19	218,000	70,000	79,000 L. A. 15,000	50,000	
	1	.21	9,330,000	800,000	1,000,000 L. A. 800,000	900,000	
63	0	.18	[b] 204,000	38,000	22,000 L. A. 48,000	96,000	
	1	.19	[b] 950,000	350,000	140,000 L. A. 60,000	400,000	270,000 of total peptonizing bacteria liquefied gelatin only slightly.

[a] L. A. means B. lactis aerogenes. The colonies growing on gelatin plates which looked like typical colonies of B. lactis aerogenes were included in the counts.

[b] In these cases gelatin was used instead of agar.

TABLE V.—*Raw and pasteurized milk at Boston, Mass., examined during November and December, 1908, and January, 1909—Milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per. c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
65	0	0.24	22,400	20,000	6,000	32,000	Samples 65 to 89, inclusive from dairy A pasteurized at 60°-65.6° C. (140° - 150° F.) "holder" process.
	1	.29	3,500,000	1,900,000	0	600,000	
67	0	.30	118,000	6,000	96,000 L. A. 11,000	3,000	
	1	.33	39,900,000	1,400,000	10,800,000 L. A. 200,000	6,300,000	
69	0	....	41,000	2,700	2,200 L. A. 400	40,000	Some alkali forms, probably lactic-acid bacteria.
	1	.18	880,000	90,000	10,000	690,000	Do.
71	0	.18	46,550	3,000	34,000	11,700	
	1	.19	214,000	100,000	250,000	80,000	
73	0	.18	36,000	1,000	18,300	15,400	
	1	.19	[a] 1,970,000	120,000	....	1,850,000	Probably the alkali formers had a large percentage of acid forms.
75	0	.18	69,200	15,000	145,000	15,000	
	1	:18	1,750,000	100,000	660,000	380,000	
77	0	.18	62,800	2,800	3,400	50,000	
	1	.20	800,000	100,000	....	1,300,000	Dilution too high.
79	0	.18	29,300	600	25,000 L. A. 8,000	10,000	
	1	.18	50,000	....	30,000	....	Do.
81	0	.18	17,900	0	36,000	5,000	No peptonizing bacteria in 1:1,000 dilution.
	1	.18	120,000	....	....	....	Gelatin liquefied.
83	0	.18	45,300	1,000	22,000	1,000	
	1	.18	....	....	....	....	Plates contaminated.
85	0	.18	6,000	0	6,000	3,000	No peptonizing bacteria in 1:100 dilution.
	1	....	....	....	....	....	
87	0	.18	19,700	3,000	32,000	....	Lactic-acid bacteria and alkali formers indistinguishable.
	1	.18	....	....	....	....	Plates contaminated.
	2	....	....	....	....	....	
	3	.31	467,000,000	....	350,000,000 (Agar.)	....	Gelatin lost.
	4	.42	656,000,000	....	....	....	Slightly sour, cheesy; total bacteria mostly acid.
89	0	.18	....	....	....	....	Plates contaminated.
	1	.18	[a] 132,000	21,000	45,000	66,000	
	2	....	....	....	....	....	
	3	.19	[a]26,100,000	2,700,000	2,800,000 L. A. 600,000	20,000,000	
	4	.41	[a]300,000,000	6,000,000	200,000,000 L. A. 30,000,000	64,000,000	
123	0	.20	140,000	....	....	....	Samples 123-133, inclusive, from dairy A pasteurized 60°-65.6° C. (140°-150° F.) "holder" process.
	1	....	....	....	....	....	
	2	.24	15,000,000	0	0	19,200,000	No peptonizing or lactic acid bacteria in 1:100,000 dilution.
	3	.39	21,300,000	3,400,000	L. A. 1,000,000	....	Slightly sour.
	4	....	184,000,000	6,000,000	56,000,000	76,000,000	

[a] In these cases gelatin was used instead of agar.

TABLE V.—*Raw and pasteurized milk at Boston, Mass., examined during November and December, 1908, and January, 1909—Milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
125	0	0.14	10,240,000	....	....	....	Gelatin plates liquefied.
	1	.18	148,000,000	600,000	27,400,000 L. A. 1,800,000	9,900,000	
	2	....	200,000,000	9,000,000	43,000,000 L. A. 30,000,000	15,000,000	
	3	.36	....	....	....	....	Slightly sour.
129	0	.14	14,100	2,000	0	7,000	No lactic-acid bacteria in 1:1,000 dilution.
	1	.15	[a]2,400,000	700,000	0	1,700,000	No lactic-acid bacteria in 1:100,000 dilution.
	2	.15	[a]35,000,000	10,000,000	L. A. 1,000,000	24,000,000	
	3	....	....	....	....	....	
	4	.28	[a]263,000,000	21,000,000	172,000,000 L. A. 15,000,000	55,000,000	
	5	.45	[a]700,000,000	50,000,000	520,000,000 L. A. 30,000,000	100,000,000	Slightly sour.
131	0	.14	[a]35,000	8,000	1,000	26,000	
	1	.14	[a]2,400,000	200,000	0	2,200,000	No lactic-acid bacteria in 1:100,000 dilution.
	2	....	....	....	....	....	
	3	.15	[a]77,000,000	6,000,000	12,000,000 L. A. 10,000,000	49,000,000	
	4	.19	[a]400,000,000	10,000,000	100,000,000	290,000,000	
	5	.32	....	....	....	....	Slightly sour.
133	0	.14	[a]12,000	1,500	500	10,000	
	1	....	....	....	....	....	
	2	.14	[a]14,400,000	1,400,000	100,000 L. A. 100,000	12,800,000	
	3	.19	[a]54,000,000	5,000,000	16,000,000	33,000,000	
	4	.36	....	....	....	....	Slightly sour.
91	0	.20	74,880,000	....	....	....	Gelatin plates liquefied. Samples 91-92, inclusive, from dairy C; total bacteria mostly acid colonies; pasteurized 71.1°-73.8° C. (160°-165° F.) "flash" process.
	1	.34	443,000,000	....	....	....	
	2	.87	....	....	....	....	
93	0	.19	3,700,000	800,000	2,500,000	0	No alkali formers in 1:100,000 dilution.
	1	.20	95,000,000	2,000,000	1,000,000	7,600,000	Sour on fourth day.
95	0	.27	17,000,000	1,700,000	100,000	4,000,000	
	1	.41	475,000,000	10,000,000	120,000,000 L. A. 40,000,000	20,000,000	
	2	.72	....	....	....	....	Sour.
97	0	.19	4,300,000	....	....	....	Gelatin liquefied.
	1	.27	17,500,000	900,000	18,000,000 L. A. 2,300,000	1,200,000	
	2	.49	202,000,000	10,000,000	160,000,000 L. A. 6,000,000	10,000,000	
	3	.81	....	....	....	....	Sour and cheesy.
99	0	.24	1,580,000	....	....	....	Gelatin liquefied.
	1	.26	71,000,000	200,000	9,400,000	1,700,000	
	2	.49	....	....	....	....	Slightly sour.
101	0	.18	2,200,000	100,000	420,000	360,000	
	1	.22	52,250,000	....	....	....	Gelatin liquefied; total bacteria mostly acid colonies.
103	0	.22	12,000	....	....	....	Gelatin liquefied.
	1	.26	106,000,000	8,000,000	45,000,000	33,000000,	
	2	.50	239,000,000	7,000,000	165,000,000 L. A. 16,000,000	20,000,000	Slightly sour.

[a] In these cases gelatin was used instead of agar.

TABLE V.—*Raw and pasteurized milk at Boston, Mass., examined during November and December, 1908, and January, 1909—Milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
105	0	0.18	37,000	....	....	....	Gelatin liquefied.
	1	.21	120,000,000	3,000,000	15,000,000	14,000,000	
	2	.40	309,000,000	20,000,000	250,000,000	0	Slightly sour; no alkali formers in 1 : 10,000,000 dilution.
107	0	.19	1,760,000	200,000	600,000 L. A. 100,000	200,000	
	1	.23	33,500,000	600,000	20,000,000 L. A. 3,200,000	3,400,000	
	2	.36	65,000,000	1,000,000	50,000,000 L. A. 10,000,000	3,000,000	Slightly sour.
109	0	.19	2,660,000	210,000	60,000	1,180,000	
	1	.25	44,200,000	7,000,000	10,000,000 L. A. 14,000,000	200,000,000	
	2	.36	60,000,000	2,000,000	46,000,000 L. A. 1,000,000	7,000,000	Do.
111	0	.19	4,900,000	3,000,000	700,000 L. A. 300,000	3,000,000	
	1	.23	63,000,000	2,100,000	10,200,000 L. A. 1,400,000	12,500,000	
	2	.42	21,000,000 [a]89,000,000	2,000,000	63,000,000 L. A. 6,000,000	18,000,000	Do.
113	0	.19	2,970,000	150,000	600,000	1,000,000	
	1	.19	8,200,000	1,000,000	6,000,000 L. A. 300,000	1,500,000	
	2	.29	[a]92,000,000	1,000,000	67,000,000 L. A. 4,000,000	20,000,000	
115	0	.19	2,060,000	40,000	2,500,000 L. A. 100,000	0	No alkali formers in 1 : 100,000 dilution.
	1	.19	8,800,000	200,000	8,000,000 L. A. 300,000	2,000,000	
	2	.29	[a]76,000,000	3,000,000	58,000,000 L. A. 6,000,000	9,000,000	
	3	.55	....	....	....	....	Sour.
117	0	.22	210,000	10,000	340,000	50,000	
	1	.25	[a]32,000,000	3,000,000	16,000,000 L. A. 1,000,000	12,000,000	
	2	.34	[a]214,000,000	3,000,000	45,000,000 L. A. 12,000,000	154,000,000	
119	0	.22	[a]1,140,000	20,000	1,050,000 L. A. 10,000	60,000	
	1	.25	[a]6,000,000	1,000,000	5,000,000	0	Gelatin dilution too high; no alkali formers in 1 : 1,000,000 dilution.
	2	.36	[a]65,000,000	1,000,000	55,000,000 L. A. 1,000,000	8,000,000	Slightly sour.
121	0	.19	[a]1,410,000	310,000	450,000 L. A. 30,000	620,000	
	1	.24	[a]11,200,000	900,000	400,000 L. A. 900,000	8,000,000	Sour on third day.

RAW MILK.

141	0	....	107,000,000	1,000,000	30,000,000 L. A. 6,000,000	8,000,000	Samples 141 and 143 (inclusive). From stores, raw milk.
	1	0.45	563,000,000	6,000,000	....	15,000,000	Slightly sour; large number of lactic-acid bacteria; could not be counted.

[a] In these cases gelatin was used instead of agar.

TABLE V.—*Raw and pasteurized milk at Boston, Mass., examined during November and December, 1908, and January, 1909—Milk held at 10° C. (50° F.)*—Continued.

RAW MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
143	0	....	15,300,000	400,000	6,000,000 L. A. 500,000	1,600,000	Could not estimate lactic acid and alkali forming bacteria; too many colonies.
	1	0.33	195,000,000	2,500,000	....	....	
	2	.45	[a]440,000,000	20,000,000	420,000,000	....	Slightly sour.
145	0	.18	160,000	....	....	....	Gelatin plates liquefied. Samples of raw milk from dairy G, No. 145-185, inclusive.
	1	.19	4,460,000	....	....	....	
	2	....	....	....	....	....	
	3	.36	763,500,000	50,000,000	....	....	Gelatin partially liquefied.
	4	.52	1,450,000,000	20,000,000	700,000,000	200,000,000	Slightly sour and slightly bitter.
147	0	.18	50,000	....	....	....	Gelatin plates liquefied.
	1	.19	2,730,000	120,000	....	2,800,000	Lactic-acid bacteria did not show.
	2	.19	69,000,000	3,000,000	20,000,000	30,000,000	
	3	.42	910,000,000	2,500,000	....	....	Slightly bitter; lactic acid and alkali forming bacteria were mostly acid colonies.
149	0	.20	[a] 7,100	2,600	600 L. A. 300	3,600	
	1	.23	[a] 118,000	49,000	L. A. 5,000	64,000	
	2	.23	[a] 4,600,000	2,600,000	0	2,000,000	No lactic-acid bacteria in 1 : 100,000 dilution.
	3	.24	[a]27,000,000	7,000,000	L. A. 5,000,000	15,000,000	
	4	.28	[a]74,000,000	8,000,000	15,000,000 L. A. 18,000,000	39,000,000	
	5	.31	[a]160,000,000	18,000,000	67,000,000 L. A. 55,000,000	20,000,000	
151	0	.23	[a] 24,400	2,100	4,200 L. A. 200	17,900	
	1	.23	[a] 2,100,000	100,000	1,400,000	600,000	
	2	.23	[a] 9,200,000	700,000	2,000,000 L. A. 100,000	6,400,000	
	3	.29	[a]48,000,000	3,000,000	25,000,000	20,000,000	
	4	.34	[a]129,000,000	6,000,000	106,000,000	16,000,000	
153	0	.20	234,000	1,000	255,000	5,000	
	1	.22	13,000,000	100,000	2,800,000	600,000	
	2	.26	25,000,000	1,000,000	18,000,000	11,000,000	
	3	.29	590,000,000	6,000,000	162,000,000 L. A. 3,000,000	34,000,000	
155	0	.21	405,000	40,000	400,000	50,000	
	1	.23	8,500,000	1,800,000	2,500,000	3,700,000	
	2	.23	151,000,000	9,000,000	22,000,000 L. A. 2,000,000	12,000,000	
157	0	.22	212,000	3,000	171,000	7,000	
	1	.22	32,900,000	200,000	9,500,000	500,000	
159	0	.16	444,500	....	....	....	Gelatin plates liquefied.
	1	.18	71,000,000	500,000	26,800,000	4,000,000	
	2	.23	240,000,000	3,000,000	134,000,000 L. A. 1,000,000	20,000,000	
	3	.38	641,000,000	12,000,000	....	....	Slightly sour; lactic acid and alkali forming bacteria could not be counted.
161	0	.17	401,000	....	....	....	Gelatin plates liquefied.
	1	.18	[a]30,900,000	1,000,000	26,100,000 L. A. 200,000	3,600,000	
	2	.29	370,000,000	5,000,000	90,000,000	200,000,000	
	3	.47	....	....	....	....	Sour.

[a] In these cases gelatin was used instead of agar.

TABLE V.—*Raw and pasteurized milk at Boston, Mass., examined during November and December, 1908, and January, 1909—Milk held at 10° C. (50° F.)*—Continued.

RAW MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
163	0	0.18	96,000,000	45,000	....	....	Could not be counted.
	1	.23	218,000,000	5,000,000	100,000,000	40,000,000	
	2	.75	....	....	....	....	Sour.
165	0	.18	102,000,000	....	....	....	Gelatin plates could not be counted.
	1	.22	119,000,000	15,000,000	(a)	(a)	Sour.
167	0	.15	2,900,000	150,000	....	....	A few acid and large number of alkali colonies. Could not estimate.
	1	.16	56,000,000	430,000	41,000,000	17,200,000	
	2	.25	284,000,000	10,000,000	210,000,000	45,000,000	
	3	.45	731,000,000	0	600,000,000 L. A. 10,000,000	50,000,000	
	4	.74	....	....	....	....	
169	0	.16	3,180,000	130,000	(a)	(a)	
	1	.17	150,000,000	....	....	....	Gelatin plates liquefied.
	2	.26	360,000,000	5,000,000	270,000,000	38,000,000	
	3	.47	681,000,000	10,000,000	770,000,000	30,000,000	
170	0	.17	91,000	30,000	9,000	....	Numerous alkali colonies grouped together.
	1	.17	3,170,000	900,000	1,200,000	1,800,000	
	2	.17	37,700,000	2,600,000	9,900,000 L. A. 200,000	14,500,000	
	3	.27	298,000,000	4,000,000	167,000,000	30,000,000	
171	0	.16	102,000	....	....	....	Plates liquefied.
	1	.16	4,500,000	300,000	700,000	3,390,000	
	2	.17	16,800,000	1,700,000	14,600,000 L. A. 500,000	20,900,000	
	3	.33	545,000,000	....	180,000,000	....	Gelatin contaminated; lactic-acid bacteria determined on agar.
173	0	.14	128,000	60,000	30,000	30,000	
	1	.14	2,040,000	250,000	560,000 L. A. 30,000	960,000	
	2	.15	59,000,000	1,700,000	28,300,000	15,500,000	
	3	.25	620,000.000	10,000.000	250,000,000	70,000,000	
	4	.40	635,000,000	10,000,000	62,000,000	60,000,000	Slightly sour.
175	0	.14	133,000	30,000	50,000	50,000	
	1	.15	2,170,000	300,000	820,000	880,000	
	2	.17	107,000,000	....	14,000,000 (Agar.)	....	Gelatin liquefied.
	3	.26	420,000,000	....	....	....	Do.
	4	.42	663,000,000	6,000,000	70,000,000	29,000,000	Slightly sour.
177	0	.14	894,000	50,000	210,000 L. A. 20,000	830,000	
	1	.16	30,900,000	....	5,600,000 (Agar.)	....	Gelatin liquefied; lactic-acid bacteria determined on agar.
	2	.20	212,000,000	2,000,000	34,000,000	129.000,000	
	3	.30	560,000,000	80,000,000	200,000,000	50,000,000	
	4	.63	....	....	....	....	Sour.
179	0	.14	583,000	....	....	....	Gelatin liquefied.
	1	.15	50,000,000	....	....	....	Do.
	2	.18	130,000,000	20,000,000	60,000,000	70,000,000	
	3	.31	[b]360,000,000	19,000,000	240,000,000 L. A. 11,000,000	90,000,000	
181	0	.14	390,000	20,000	220,000	70,000	
	1	.15	19,000,000	1,200,000	20,000,000	4,000,000	
	2	.19	[b]185,000,000	5,000,000	67,000,000	113,000,000	
	3	.32	[b]320,000,000	5,000,000	275,000,000	40,000,000	

[a] Not estimated.

[b] In these cases gelatin was used instead of agar.

TABLE V.—*Raw and pasteurized milk at Boston, Mass., examined during November and December, 1908, and January, 1909—Milk held at 10° C. (50° F.)*—Continued.

RAW MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
183	0	0.15	580,000	....	....	....	Gelatin liquefied.
	1	.17	[a]35,600,000	1,500,000	24,000,000 L. A. 1,300,000	8,800,000	
	2	.36	[a]336,000,000	2,000,000	306,000,000 L. A. 3,000,000	25,000,000	
185	0	.15	[a]128,000	4,000	109,000 L. A. 3,000	12,000	
	1	.15	[a]18,000,000	700,000	11,100,000 L. A. 1,400,000	4,800,000	
	2						
	3	.44	....	....	....	....	Slightly sour.

[a] In these cases gelatin was used instead of agar.

TABLE VI.—*Raw and pasteurized milk at Boston, Mass.—Examination of winter milk held at room temperature, 21.1° C. (70° F.).*

PASTEURIZED MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
46	0	....	21,200	4,000	15,400	5,500	From dairy B, No. 46 to 64 (inclusive). Pasteurized (140-150° F.) 60-65.6° C. "flash" process.
	1	0.22	44,000,000	4,800,000	30,500,000 L. A. 800,000	7,900,000	
48	0	.18	34,000	4,600	1,200 L. A. 200	10,000	
	1	27	217,000,000	7,000,000	200,000,000	33,000.000	
50	0	.19	41,200	3,000	32,000	10.000	
	1	.24	302,000,000	8,000,000	207,000,000 L. A. 4,000,000	9,000,000	
52	0	.20	230,000	23,000	39,000 L. A. 79,000	60,000	
	1	.23	....	....	....	....	
54	0	.19	145,000	9,000	60,000	50,000	
	1	.24	576,000,000	30,000,000	280,000,000	120,000,000	
56	0	.24	31,400	4,000	36,000 L. A. 11,000	8,000	
	1	.39	408,000,000	9,000,000	370,000,000 L. A. 26,000,000	19,000,000	
58	0	.34	206,000	19,000	100,000 L. A. 11,000	6,000	
	1	.71	549,000,000	2,000,000	480,000,000 L. A. 58,000,000	0	Sour.
60	0	.32	223,000	12,000	200,000 L. A. 500,000	45,000	
	1	.58	273,000,000	1,000,000	253,000,000 L. A. 24,000,000	117.000,000	Slightly sour.
62	0	.18	255,000	19,000	62,000 L. A. 34,000	40,000	
	1	.34	190,000,000	12,000,000	72,000,000 L. A. 21,000,000	125,000,000	
64	0	.18	193,000	5,000	140,000 L. A. 19,000	26,000	
	1	.27	295,000,000	4,000,000	286,000,000 L. A. 14,000,000	96,000,000	

TABLE VI.—*Raw and pasteurized milk at Boston, Mass.—Examination of winter milk held at room temperature, 21.1° C. (70° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
66	0	0.25	14,500,000	(a)	[b] 6,700	(a)	From dairy A, No. 66 to 88 (inclusive. Pasteurized (140–150° F.) 60–65.6° C., "holder" process.
	1	.29	70,000,000	11,000,000	30,000,000 L. A. 4,000,000	33,000,000	
68	0	.27	63,000	8,000	40,000	0	
	1	.72	380,000,000	20,000,000	200,000,000 L. A. 4,000,000	29,000,000	Sour.
70	0	.27	61,000	1,000	27,000		Acid or alkali.
	1		143,000,000	8,000,000	107,000,000 L. A. 3,000,000	33,000,000	
72	0	.18	51,800	2,000	29,000	19,200	
	1	.22	16,000,000	5,000,000	19,000,000	4,000,000	
74	0	.16	28,300	2,400	20,000	9,200	
	1	.18	10,200,000	13,000,000	11,000,000	17,000,000	
76	0	.18	172,000	23,000	176,000	13,000	
	1	.27	276,000,000	5,000,000	250,000,000	44,000,000	
78	0	.18	78,600	1,400	3,500	61,000	
	1	.19	16,900,000	2,000,000	14,000,000	19,000,000	
80	0	.18	63,100	1,000	30,000 L. A. 6,000	15,000	
	1	.27	17,000,000	300,000	8,000,000 L. A. 100,000	2,800,000	
82	0	.18	20,200	100	13,000	25,000	
	1	.19	72,000,000	10,000,000	20,000,000	10,000,000.	Count not accurate; dilution too high.
	2	.90					Sour, curdled.
84	0	.18	46,000	300	30,000		Acid or alkali.
	1	.18	24,000,000				Gelatin liquefied.
86	0	.18	6,900				Do.
	1	.18	14,800,000				Do.
	2	.52					Sour.
88	0	.18	86,200	100	83,000		
	1	.18	150,000,000				Gelatin liquefied.
	2	.89					Sour, curdled.
92	0	.20	79,640,000				Gelatin liquefied. From dairy C, No. 92 to 102; also 122.
	1	.58	120,960,000,000				Gelatin liquefied; sour.
	2	1.03					Mostly acid colonies, pasteurized, "flash" process, 160° F. (76.7° C.).
94	0	.20	3,700,000	800,000	2,500,000	0	
	1	.35	7,040,000,000	9,000,000	93,000,000 L. A. 7,000,000	95,000,000	Slightly sour.
96	0	.28	16,900,000	250,000	3,000,000	5,000,000	
	1	.94					Curdled, gas.
98	0	.24	4,300,000	60,000	0	80,000	Plates were partially liquefied.
	1	.56	1,088,000,000	3,000,000	[a] 3,500,000 900,000,000 L. A. 30,000,000	60,000,000	Slightly sour.
100	0	.24	1,560,000				
	1	.71					

[a] Plate liquefied.

[b] On agar.

Table VI.—*Raw and pasteurized milk at Boston, Mass.—Examination of winter milk held at room temperature, 21.1° C. (70° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
102	0	0.18	1,400,000	70,000	700,000	100,000	
	1	.58	830,000,000	12,000,000	......	......	Gelatin liquefied; slightly sour; could not be used.
122	0	.19	[a] 4,200,000	100,000	2,500,000 L. A. 100,000	1,500,000	
	1	.40	77,000,000	7,000,000	50,000,000 L. A. 2,000,000	18,000,000	

RAW MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
142	0	......	107,000,000	......	......	......	Raw milk from stores, No. 142 to 144.
	1	0.42	573,000,000	3,000,000	[b] 500,000,000 L. A. 37,000,000	4,000,000	
	2	.55	......	......	......	......	Sour.
144	0	......	15,300,000	......	......	......	
	1	.37	305,000,000	3,000,000	......	......	Gelatin liquefied.
	2	.81	......	......	......	......	Sour.
146	0	.18	302,000				Gelatin liquefied. Raw milk from dairy G, No. 146 to 152.
	1	.20	81,800,000	......	......	......	
	2	......	......				
148	0	.18	50,300	......	......	......	Gelatin liquefied.
	1	.19	34,900,000	1,000,000	......	......	Plates badly liquefied; few acid and numerous alkali.
	2	.90	......	......	......	......	Sour, curdled.
150	0	.20	18,000	1,700	500 L. A. 900	2,700	
	1	.23	[a]105,000,000	5,000,000	80,000,000	20,000,000	
	2	......	......	......	......	......	Do.
152	0	.22	83,500	4,100	76,800	2,600	
	1	.81	......	......	......	......	Do.

[a] Gelatin. [b] Approximate.

Table VII.—*Raw and pasteurized milk at Boston, Mass.—Examination of summer milk held at 10° C. (50° F.).*[a]

PASTEURIZED MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria on litmus lactose gelatin.	Remarks.
271	0	0.18	15,500,000	1,900,000	83,200,000		Mostly lactic forms. Samples Nos. 271-283 from dairy A.
	1	.31	100,000,000	3,000,000	115,000,000 L. A.[b] 26,000,000	9,000,000	
	2	.78	......	......	......	......	Curdled.

---

[a] 10° C. (50° F.) is used to show that milk was held in the refrigerator. During this series in June the temperature of the refrigerator probably ranged between 10° C. (50° F.) and 15° C. (59° F.).

[b] L. A. means B. lactis aerogenes. The colonies growing on gelatin plates which looked like typical colonies of B. lactis aerogenes were included in the counts.

TABLE VII.—*Raw and pasteurized milk at Boston, Mass.—Examination of summer milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria on litmus lactose gelatin.	Remarks.
272	0	0.15	140,000	5,600	6,000 L. A. 62,000	372,000	
	1	.15	9,600,000	220,000	70,000 L. A. 750,000	1,700,000	
	2	.22	200,000,000	8,000,000	98,000,000 L. A. 88,000,000	20,000,000	Slightly sour; cheesy.
273	0	.15	42,000	6,000	1,000 L. A. 2,000	88,000	
	1	.15	20,000,000	3,600,000	16,500,000 L. A. 17,400,000	18,700,000	
	2	.24	247,000,000	2,000,000	206,000,000 L. A. 107,000,000	0	Slightly sour.
274	0	.15	580,000	70,000	434,000 L. A. 50,000	230,000	
	1	.15	25,700,000	6,000,000	7,000,000 L. A. 11,000,000	20,000,000	
275	0	.15	24,000	6,000	1,000 L. A. 1,000	19,000	
	1	.15	2,490,000	1,100,000	0	1,600,000	
	2	.15	19,000,000	2,000,000	600,000 L. A. 6,800,000	12,600,000	
	3	.16	71,000,000	5,000,000	4,000,000 L. A. 28,000,000	40,000,000	Old taste; would not be used.
276	0	.15	12,000	....	....	....	No counts.
	1	.15	170,000	20,000	0	270,000	
	2	.15	6,000,000	2,000,000	1,000,000 L. A. 1,000,000	1,000,000	
	3	......	....	....	....	....	
	4	.47	....	....	....	....	Sour and cheesy.
277	0	.15	197,000	21,000	17,000	57,000	
	1	.15	16,300,000	2,700,000	1,800,000	17,800,000	
	2	......	....	....	....	....	
	3	1.25	....	....	....	....	Sour; curdled.
278	0	.14	20,000	1,000	7,000 L. A. 1,000	17,000	
	1	......	....	....	....	....	
	2	.27	183,000,000	8,000,000	226,000,000 L. A. 23,000,000	67,000,000	
	3	.74	....	....	....	....	Do.
279	0	.15	194,000	45,000	32,000 L. A. 16,000	193,000	
	1	.15	43,000,000	8,000,000	6,000,000 L. A. 11,000,000	65,000,000	
	2	.23	333,000,000	2,000,000	75,000,000 L. A. 53,000,000	31,000,000	Slightly sour.
280	0	.15	38,000	....	....	....	No elating counts.
	1	.15	27,300,000	200,000	400,000 L. A. 8,800,000	20,000,000	
	2	.15	92,000,000	600,000	....	....	Large number of acid colonies; plate could not be counted; slightly old taste.
	3	.54	....	....	....	....	Slightly sour; cheesy.
281	0	.15	144,000	4,000	L. A. 64,000	75,000	
	1	.15	15,500,000	500,000	L. A. 1,800,000	8,500,000	
	2	.19	165,000,000	700,000	L. A. 100,000	30,000	
	3	.28	....	....	....	....	Slightly old taste.
282	0	.15	321,000	....	....	....	Gelatin liquefied.
	1	.15	21,200,000	....	....	....	Do.
	2	......	....	....	....	....	
	3	.27	....	....	....	....	Slightly sour.
283	0	.15	20,000	....	....	....	Gelatin liquefied.
	1	......	....	....	....	....	
	2	.15	86,000,000	....	....	....	Do.
	3	.23	294,000,000	....	....	....	Gelatin liquefied; slightly sour and cheesy.

Table VII.—*Raw and pasteurized milk at Boston, Mass.—Examination of summer milk held at 10° C. (50° F.)*—Continued.

RAW MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria on litmus lactose gelatin.	Remarks.
284	0	0.17	[a] 2,570,000	200,000	700,000 L. A. 170,000	1,500,000	Raw milk from stores, Nos. 284 to 293.
	1	.20	[a] 95,000,000	6,000,000	25,000,000 L. A. 2,000,000	62,000,000	
	2	.9					Curdled.
285	0	.17	[a] 13,900,000	1,500,000	10,000,000 L. A. 900,000	1,500,000	
	1	.25	[a] 85,000,000	1,000,000	57,000,000 L. A. 11,000,000	16,000,000	
	2	.72					Partly curdled.
286	0	.17	[a] 5,000,000	0	1,000,000	4,000,000	
	1	.39	[a] 238,000,000	6,000,000	172,000,000 L. A. 10,000,000	50,000,000	
	2	.68					Sour.
287	0	.17	[a] 9,700,000	300,000	6,500,000 L. A. 500,000	2,400,000	
	1	.33	[a] 164,000,000	11,000,000	53,000,000 L. A. 26,000,000	74,000,000	
		.60					Sour.
288	0	.18	10,000,000	3,000,000	18,000,000 L. A. 1,000,000	6,200,000	
	1	.34	568,000,000	0	500,000,000 L. A. 4,000,000	1,000,000	
	2	.92					Curdled.
289	0	.24	50,100,000	400,000	40,000,000 L. A. 1,200,000	1,500,000	
	1	.36	299,000,000	1,000,000	4,000,000 L.A. 195,000,000	0	Slightly sour.
290	0	.16	7,000,000	300,000	6,700,000 L. A. 600,000	1,200,000	
	1	.19	135,000,000	5,000,000	68,000,000 L. A. 17,000,000	16,000,000	
291	0	.16	7,700,000	600,000	8,700,000 L. A. 900,000	1,200,000	
	1	.20	162,000,000	1,000,000	104,000,000 L. A. 11,000,000	8,000,000	
292	0	.16	4,430,000	2,100,000	7,100,000	2,000,000	
	1	.22	144,000,000	10,000,000	86,000,000 L. A. 14,000,000	67,000,000	
	2	.22	254,000,000	4,000,000	141,000,000 L. A. 13,000,000	0	Old taste.
293	0	.16	5,400,000	1,000,000	900,000 L. A. 500,000	2,100,000	
	1	.19	91,000,000	8,000,000	21,000,000 L. A. 3,000,000	47,000,000	
	2	.35	162,000,000	32,000,000	61,000,000 L. A. 24,000,000	342,000,000	
	3						
	4	.91					Curdled.
294	0	.15	3,900,000	200,000	620,000 L. A. 140,000	940,000	Raw milk from dairy E, Nos. 294-299.
	1	.15	21,300,000	800,000	5,600,000 L. A. 2,100,000	10,000,000	
	2						
	3	1.5					Curdled; gas.
295	0	.15	3,600,000	140,000	1,800,000 L. A. 230,000	880,000	
	1						
	2	.81					Curdled.

[a] Gelatin.

TABLE VII.—*Raw and pasteurized milk at Boston, Mass.—Examination of summer milk held at 10° C. (50° F.)*—Continued.

RAW MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria on litmus lactose gelatin.	Remarks.
297	0	0.17	18,200,000	...	...	...	Gelatin liquefied.
	1	.18	229,000,000	70,000,000	5,000,000	160,000,000	
	2	.39	...	...	...	...	Slightly sour.
298	0	.15	4,400,000	460,000	1,100,000 L. A. 40,000	1,800,000	
	1	.18	125,000,000	0	50,000,000 L. A. 10,000,000	20,000,000	
	2	.57	1,100,000,000	...	...	...	Gelatin liquefied; milk sour.
299	0	.15	7,700,000	100,000	600,000	5,000,000	
	1	.23	268,000,000	(a) 0	120,000,000	80,000,000	
	2	...	...	...	...	...	
	3	.64	...	...	...	...	Curdled; gas.
300	0	.15	29,200,000	...	...	...	Gelatin liquefied; raw milk from dairy F. Nos. 300 to 305.
	1	...	...	...	...	...	
	2	.43	304,000,000	...	...	...	Gelatin liquefied.
	3	.90	...	...	...	...	Curdled.
301	0	.16	15,000,000	...	...	...	Gelatin liquefied.
	1	.29	136,000,000	...	...	...	Do.
	2	.76	...	...	...	...	Sour gas; slightly putrid taste.
302	0	.16	76,800,000	...	...	...	Gelatin liquefied.
	1	.67	...	...	...	...	Sour; gas.
303	0	.20	43,100,000	...	...	...	Gelatin liquefied.
	1	.54	300,000,000	...	...	...	Do.
	2	.94	...	...	...	...	Curdled.
304	0	.18	133,000,000	...	...	...	Gelatin liquefied.
	1	.56	...	...	...	...	Sour.
305	0	.18	1,100,000	...	...	...	Gelatin liquefied.
	1	.27	192,000,000	...	...	...	Do.

RAW AND PASTEURIZED MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria on litmus lactose gelatin.	Remarks.
[b] 306	0	0.15	1,760,000	220,000	560,000	330,000	From dairy B, pasteurized "flash" process, 60°-65.6° C. (140°-150° F.), samples Nos. 306-323, inclusive.
	1	.15	3,390,000	400,000	4,400,000	1,000,000	
	2	.30	75,000,000	3,000,000	34,000,000 L. A. 1,000,000	50,000,000	Slightly sour.
	3	.42	...	...	...	...	Sour.
[b] 307	0	.15	1,450,000	100,000	900,000 L. A. 100,000	300,000	
	1	.15	9,900,000	100,000	8,000,000	1,000,000	
	2	.27	328,000,000	4,000,000	45,000,000	240,000,000	
	3	.43	...	...	...	...	Slightly sour.
[c] 308	0	.16	14,500,000	500,000	2,600,000 L. A. 1,000,000	3,000,000	
	1	.19	26,000,000	6,000,000	37,000,000 L. A. 4,000,000	20,000,000	
	2	.64	...	...	...	...	Sour.
[b] 309	0	.15	6,300,000	100,000	3,000,000	1,700,000	
	1	.16	108,000,000	3,000,000	3,000,000	32,000,000	
	2	...	...	...	...	...	
	3	.45	856,000,000	...	...	...	Slightly sour.

[a] Liquid in 1,000,000 dilutions.

[b] Pasteurized.

[c] Raw.

TABLE VII.—*Raw and pasteurized milk at Boston, Mass.—Examination of summer milk held at 10° C. (50° F.)*—Continued.

RAW AND PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria on litmus lactose gelatin.	Remarks.
[a] 310	0	0.15	1,210,000				Gelatin liquefied.
	1						
	2	.26	205,000,000				
	3	.82					Sour.
[b] 311	0	.15	23,600,000	700,000	5,800,000 L. A. 1,300,000	7,400,000	
	1						
	2	.42	292,000,000				Slightly sour.
	3	.78					Curdled.
[a] 312	0	.15	215,000				
	1	.19	91,000,000				
	2	.74					Sour.
[b] 313	0	.15	8,900,000				
	1	.25	139,000,000				
	2	.64					Do.
[a] 314	0	.15	16,900,000				
	1	.33	42,000,000				
	2	.72					Do.
[b] 315	0	.24	48,000,000	1,400,000			
	1	.74					Do.
[a] 316	0	.15	4,095,000				
	1	.22	151,000,000				
	2	1.02					
[b] 317	0	.18	12,600,000				
	1	.54	280,000,000				Slightly sour.
	2	.90					Curdled.
[a] 318	0	.15	1,940,000				
	1	.20	130,000,000				
	2	.65					Sour.
[b] 319	0	.18	32,000,000				
	1	.38	60,000,000				Do.
		.59					
[a] 320	0	.15	4,100,000				
	1	.36	361,000,000				
321	0	.18	79,000,000				
	1	.90					Curdled.
[a] 322	0	.15	31,200,000				
[b] 323	0	.18	111,000,000				

[a] Pasteurized. [b] Raw.

In the above table of raw and pasteurized milk from dairy B the samples of milk were taken from the dairy at the same time they would have been delivered to the public and when first examined were 24 hours old. When two samples such as pasteurized 307 and raw 308 are placed together, it shows that the samples were taken the same day, before and after pasteurization at the dairy and then allowed to remain in the dairy refrigerator until the next day in order to duplicate commercial conditions.

TABLE VIII.—*Raw and pasteurized milk at Boston, Mass.—Total bacterial counts and group percentages—Milk held at 10° C. (50° F.).*

PASTEURIZED MILK—DAIRY B.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
45	0	36,400	13.46	61.53	24.99
	1	142,000	8.45	61.26	30.28
47	0	28,300	16.96	53.71	29.32
49	0	40,700	8.35	82.55	9.09
	1	260,000	11.53	50.00	38.46
51	0	205,000	3.414	62.43	34.14
	1	2,100,000	4.76	66.66	28.57
53	0	124,000	4.83	70.96	24.19
55	0	117,000	10.25	55.55	34.18
	1	280,000	53.57	21.42	25.00
57	0	220,000	4.54	81.81	13.63
	1	7,800,000	6.41	60.25	33.33
59	0	529,000	8.50	78.26	13.23
	1	7,820,000	4.21	90.02	5.75
61	0	214,000	32.71	43.92	23.36
	1	3,500,000	22.85	51.42	25.71
63	0	204,000	18.62	34.31	47.05
	1	950,000	36.84	21.05	42.10

PASTEURIZED MILK—DAIRY A.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
67	0	116,000	5.17	92.24	2.58
	1	18,700,000	7.48	58.82	33.68
69	0	45,300	5.96	5.73	88.30
	1	790,000	11.39	1.26	87.34
71	0	48,700	6.16	69.81	24.02
	1	430,000	23.25	58.13	18.60
73	0	34,700	2.88	52.73	44.38
	1	1,970,000	6.09	....	93.90
75	0	175,000	8.57	82.85	8.57
	1	1,140,000	8.77	57.89	33.33
77	0	56,200	4.98	6.04	88.96
	1	1,400,000	7.14	....	92.85
79	0	43,600	1.37	75.68	22.93
	1	30,000	....	100.00	....
81	0	41,000	....	87.80	12.19
83	0	24,000	4.16	91.66	4.16
85	0	9,000	....	66.66	33.33
89	0	....	....	....	....
	1	132,000	15.90	34.09	50.00
	2	....	....	....	....
	3	26,100,000	10.34	13.02	76.62
	4	300,000,000	2.00	76.66	21.33
123	0	....	....	....	....
	1	....	....	....	....
	2	....	....	....	....
	3	4,400,000	77.27	22.72	....
125	0	....	....	....	....
	1	39,700,000	1.51	73.55	24.93
	2	97,000,000	9.27	75.25	15.46
129	0	9,000	22.22	....	77.77
	1	2,400,000	29.16	....	70.83
	2	35,000,000	2.85	28.57	68.57
131	0	35,000	22.85	2.85	74.28
	1	2,400,000	8.33	....	91.66
	2	....	....	....	....
	3	77,000,000	7.79	28.57	63.63
133	0	12,000	12.50	4.16	83.33
	1	....	....	....	....
	2	14,400,000	9.72	1.38	88.88
	3	54,000,000	9.25	29.62	61.11

TABLE VIII.—*Raw and pasteurized milk at Boston, Mass.—Total bacterial counts and group percentages—Milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—DAIRY C.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
93	0	3,300,000	24.24	75.75	......
	1	10,600,000	18.86	9.43	71.69
95	0	5,800,000	29.31	1.72	68.96
	1	190,000,000	5.26	84.21	10.52
97	0	....	....	....	......
	1	22,400,000	4.01	90.62	5.35
	2	186,000,000	5.37	89.24	5.37
99	0	....	....	....	......
	1	11,300,000	1.76	83.18	15.04
101	0	880,000	11.36	47.72	40.99
103	0	....	....	....	......
	1	86,000,000	9.30	52.32	38.38
	2	208,000,000	3.36	87.01	9.61
105	0	....	....	....	......
	1	32,000,000	9.37	46.87	43.75
	2	270,000,000	7.40	92.59	......
107	0	1,100,000	18.18	63.63	18.18
	1	27,200,000	2.20	85.29	12.50
	2	64,000,000	1.56	93.75	4.68
109	0	1,450,000	14.48	4.13	81.37
	1	231,000,000	3.03	10.38	86.58
	2	56,000,000	3.57	83.92	12.50
111	0	7,000,000	42.85	14.28	42.85
	1	26,200,000	8.01	44.27	47.70
	2	89,000,000	2.24	77.52	20.23
113	0	1,750,000	8.57	34.28	57.14
	1	8,800,000	11.36	71.59	17.04
	2	92,000,000	1.08	77.17	21.73
115	0	2,640,000	1.51	98.48	......
	1	10,500,000	1.90	79.04	19.04
	2	76,000,000	3.94	84.21	11.84
117	0	400,000	2.50	85.0	12.5
	1	32,000,000	9.37	53.12	37.50
	2	214,000,000	1.40	26.63	71.96
119	0	1,140,000	1.75	92.98	5.26
	1	6,000,000	16.66	83.33	......
	2	65,000,000	1.53	86.15	12.30
121	0	1,410,000	21.98	34.04	43.97
	1	11,200,000	8.03	20.53	71.42

RAW MILK—DAIRY G.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
147	0	....	....	....	......
	1	2,920,000	4.10	....	95.89
	2	53,000,000	5.66	37.73	56.60
149	0	71100	36.61	12.67	50.70
	1	118,000	41.53	4.23	54.23
	2	4,600,000	56.52	....	43.47
	3	27,000,000	25.92	18.51	55.55
151	0	24,400	8.60	18.03	73.36
	1	2,100,000	4.76	66.66	28.57
	2	9,200,000	7.60	22.82	69.56
	3	48,000,000	6.25	52.08	41.66
153	0	261,000	.38	97.70	1.91
	1	3,500,000	2.85	80.00	17.14
	2	30,000,000	3.33	60.00	36.66
	3	205,000,000	2.92	80.48	16.58
155	0	490,000	8.16	81.63	10.20
	1	8,000,000	22.50	31.25	46.25
	2	45,000,000	20.00	53.33	26.66
157	0	181,000	1.65	94.47	3.86
	1	10,200,000	1.96	93.13	4.90
159	0	....	....	....	......
	1	31,300,000	1.59	85.62	12.77
	2	158,000,000	1.89	85.44	12.65
161	0	....	....	....	......
	1	30,900,000	3.23	85.11	11.65
	2	295,000,000	1.69	30.50	67.79
163	0	....	....	....	......
	1	145,000,000	3.44	68.96	27.58
167	0	....	....	....	......
	1	58,630,000	.73	69.93	29.33
	2	265,000,000	3.77	79.24	16.98
	3	660,000,000	....	92.42	7.57
169	0	....	....	....	......
	1	....	....	....	......
	2	313,000,000	1.59	86.26	12.14
	3	810,000,000	1.23	95.06	3.7
170	0	39,000	76.92	23.07	......
	1	3,900,000	23.07	30.76	46.15
	2	27,200,000	9.55	37.13	53.30
	3	201,000,000	1.99	83.08	14.92
171	0	....	....	....	......
	1	4,390,000	6.83	15.94	77.21
	2	37,700,000	4.50	40.05	55.43
173	0	120,000	50.00	25.00	25.00
	1	1,800,000	13.88	32.77	53.33
	2	45,500,000	3.73	62.19	34.06
175	0	130,000	23.07	38.46	38.46
	1	2,000,000	15.00	41.00	44.00
177	0	1,110,000	4.50	20.72	74.77
	1	....	....	....	......
	2	165,000,000	1.21	20.60	78.18
	3	330,000,000	24.24	60.60	15.15
179	0	....	....	....	......
	1	....	....	....	......
	2	150,000,000	13.33	40.00	46.66
	3	360,000,000	5.27	69.72	25.00
181	0	310,000	6.45	70.96	22.58
	1	25,200,000	4.76	79.36	15.87
	2	185,000,000	2.70	36.21	61.08
	3	320,000,000	1.56	85.94	12.50
183	0	....	....	....	......
	1	35,600,000	4.21	71.06	24.71
	2	336,000,000	.59	91.99	7.43
185	0	128,000	3.12	87.50	9.37
	1	18,000,000	3.88	69.44	26.66

Table IX.—*Raw and pasteurized milk at Boston, Mass.—Total bacterial counts and group percentages—Milk held at 21° C. (70° F.).*

PASTEURIZED MILK—DAIRY B.

Sample No.	Age of milk in days.	Total bacteria per c.c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.	Sample No.	Age of milk in days.	Total bacteria per c.c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
46	0	24,900	16.06	61.84	22.08	58	0	136,000	13.97	81.61	4.41
	1	44,000,000	10.9	71.13	17.95		1	540,000,000	.37	99.62	....
48	0	16,000	28.75	8.75	62.5	60	0	757,000	1.585	92.47	5.94
	1	240,000,000	2.91	83.33	13.75		1	395,000,000	.253	70.12	29.62
50	0	45,000	6.66	71.11	22.22	62	0	155,000	12.25	61.93	25.8
	1	228,000,000	3.50	92.54	3.94		1	230,000,000	5.21	40.43	54.34
52	0	201,000	11.44	58.70	29.85	64	0	190,000	2.631	83.68	13.68
54	0	119,000	7.56	50.42	42.01		1	400,000,000	1.00	75.00	24.00
	1	430,000,000	6.97	65.11	27.9						
56	0	59,000	6.77	79.66	13.55						
	1	424,000,000	2.12	93.39	4.48						

PASTEURIZED MILK—DAIRY A.

66	0	....	....	....	....	76	0	212,000	10.84	83.01	6.13
	1	78,000,000	14.10	43.58	42.30		1	299,000,000	1.67	83.61	14.71
68	0	48,000	16.66	83.33	....	78	0	65,900	2.12	5.31	92.56
	1	253,000,000	7.90	80.63	11.46		1	35,000,000	5.71	40.00	54.28
70	0	....	....	....	....	80	0	52,000	1.92	69.23	28.84
	1	151,000,000	5.29	72.84	21.75		1	11,200,000	2.67	72.32	25.00
72	0	50,200	3.98	57.76	38.24	82	0	38,100	26.00	34.12	65.61
	1	28,000,000	17.85	67.85	14.28		1	40,000,000	25.00	50.00	25.00
74	0	31,600	7.59	63.29	29.11	88	0	83,100	.12	99.87	....
	1	41,000,000	31.70	26.82	41.46						

PASTEURIZED MILK—DAIRY C.

94	0	3,300,000	24.24	75.75	....	102	0	870,000	8.04	80.45	11.49
	1	204,000,000	4.41	49 01	46.56	122	0	4,200,000	2.38	61.90	35.71
96	0	8,250,000	3.03	36.36	60.60		1	77,000,000	9.09	67.53	23.37
98	0	3,640,000	1.63	96.15	2.19						
	1	993,000,000	.30	93.65	6.04						

RAW MILK—DAIRY G.

142	0	....	....	....	....	152	0	83,500	4.91	91.97	3.11
	1	544,000,000	.55	98.71	.73						
150	0	5,800	29.31	24.13	46.55						
	1	105,000,000	4.76	76.19	19.04						

Table X—*Raw and pasteurized milk at Boston, Mass., in summer—Total bacterial counts and group percentages—Milk held at 10° C. (50° F.).*

PASTEURIZED MILK—DAIRY A.

Sample No.	Age of milk in days.	Total bacteria per c.c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
272	0	445,600	1.23	15.26	83.48
	1	2,740,000	8.02	29.92	62.04
	2	214,000,000	3.73	86.91	9.34
273	0	97,000	6.18	3.09	90.72
	1	56,200.000	6.40	60.32	33.27
	2	315,000 000	.63	99.36	....
274	0	784,000	8.92	61.73	29.33
	1	44,000,000	13.63	40.91	45.45
275	0	27,000	22.22	7.41	70.37
	1	2,700,000	40.74	....	59.25
	2	22,000,000	9.09	33.63	57.27
	3	77,000,000	6.49	41.55	51.94
276	0	....	....	....	....
	1	290,000	6.89	....	93.10
	2	5,000,000	40.00	40.00	20.00
277	0	95,000	22.10	17.98	60.00
	1	22,300,000	12.10	8.07	79.82
278	0	26,000	3.83	30.76	65.38
	1	....	....	....	....
	2	324,000,000	2.46	76.85	20.67
279	0	286,000	15.73	16.78	67.48
	1	90,000,000	8.88	18.88	72.22
	2	161,000,000	1.24	79.50	19.25
280	0	....	....	....	....
	1	29,400,000	.68	31.29	68.02

RAW MILK.

Sample No.	Age of milk in days.	Total bacteria per c.c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
284	0	2,570,000	7.78	33.85	58.36
	1	95,000,000	6.31	28.42	65.26
285	0	13,900,000	10.79	78.41	10.79
	1	85,000,000	1.17	80.00	18.82
286	0	5,000,000	....	20.00	80.00
	1	238,000,000	2.51	76.47	21.00
287	0	9,700,000	3.09	72.16	24.74
	0	164,000,000	6.70	48.17	45.12
288	0	28,200,000	10.63	67.37	21.98
	1	505,000,000	....	99.80	.19
289	0	43,100,000	.92	95.59	3.46
	1	200,000,000	.50	99.50	....
290	0	8,800,000	3.49	82.95	13.63
	1	106,000,000	4.71	80.18	15.09
291	0	11,400,000	5.26	84.21	10.52
	1	124,000,000	.80	92.74	6.45
292	0	11,200,000	18.75	63.39	17.85
	1	177,000,000	5.64	56.49	37.85
	2	158,000,000	2.53	97.46	....
293	0	4,500,000	22.22	31.11	46.66
	1	79,000,000	10.12	30.37	59.49
	2	459,000,000	6.97	18.51	74.50
294	0	1,900,000	10.52	40.00	49.47
	1	18,500,000	4.32	41.62	54.05
295	0	3,050,000	4.59	66.53	28.85
	1	....	....	....	....
297	0	....	....	....	....
	1	235,000,000	29.78	2.12	68.08
298	0	3,400,000	13.52	33.52	52.94
	1	80,000,000	([a])	75.00	25.00
299	0	5,700,000	1.75	10.52	87.71
	1	200,000,000	....	60.00	40.00

[a] 0 in 10,000,000 dilutions.

Table XI.—*Raw and pasteurized milk in New York City, examined February and March, 1909—Daily acidity, total bacterial counts, and group percentages—Milk held at 10° C. (50° F.).*

PASTEURIZED MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
201	0	0.21	[a]11,200	600	L. A. [b]6,400	[b]4,200	From dairy H, Nos. 201-221, inclusive, pasteurized "holder" process, 60°-65.6° C. (140°-150° F.).
	1	.22	[a]42,000	1,000	1,000	40,000	
	2	.21	[a]900,000	50,000	20,000	830,000	
	3	.21	[a]7,900,000	7,600,000	0	[c]6,300,000	
	4						
	5	.22	[a]47,100,000	2,000,000	31,500,000 L. A. 2,000,000	11,600,000	
	6						
	7	.63	[a]457,000,000	15,000,000	400,000,000	42,000,000	Sour and gas.
	8	.74	[a]575,000,000	2,000,000	540,000,000	32,000,000	
	9	.81					
203	0	.20	[a]10,000	0	1,000	9,000	
	1	.20	[a]50,000			50,000	Dilution too high.
	2	.18	[a]4,000,000	900,000	[d]3,100,000		
	3						
	4	.21	[a]21,600,000	1,100,000	2,000,000 L. A. 8,600,000	9,900,000	
	5						
	6	.41	[a]403,000,000	3,000,000	250,000,000 L.A. 100,000,000	50,000,000	Slight cheesy flavor; would not be used.
	7	.52	[a]331,000,000	2,000,000	176,000,000 L. A. 87,000,000	66,000,000	Gas.
	8	.66					
205	0	.19	[a]29,800	600	3,000	26,200	
	1	.18	[a]59,000	1,000	5,000	53,000	
	2						
	3	.20	[a]1,300,000	100,000	200,000	1,000,000	
	4						
	5	.18	[a]26,800,000	900,000	6,000,000	1,990,000	
	6	.23	[a]69,000,000	6,000,000	19,000,000 L. A. 9,000,000	35,000,000	Slight cheesy flavor.
	7	.31	[a]206,000,000	4,000,000	153,000,000	49,000,000	
	8	.56					
207	0	.18	8,300	200	1,000	8,600	
	1						
	2	.18	1,330,000	14,000	25,000	270,000	
	3						
	4	.19	18,000,000	1,300,000	3,000,000	9,800,000	
	5	.21	87,000,000	7,000,000	12,000,000 L. A. 8,000,000	26,000,000	
	6	.24	360,000,000	2,000,000	133,000,000	54,000,000	
	7	.39					
[e]209	0						
	1	.19	8,000	900	1,200	7,100	
	2						
	3	.19	3,000,000	170,000	20,000 L. A. 100,000	3,000,000	
	4	.22	24,000,000	1,000,000	900,000	17,700,000	
	5	.20	88,000,000	4,000,000	22,000,000	38,000,000	
	6	.39	360,000,000	8,000,000	156,000,000 L. A. 30,000,000	81,000,000	
	7	.63					Sour.
	8	.83					
211	0	.21	7,900	1,000	11,000	9,000	
	1						
	2	.27	2,080,000	270,000	20,000 L. A. 70,000	1,700,000	
	3	.27	14,500,000	1,000,000	400,000	14,500,000	
	4	.24	63,000,000	3,000,000	26,000,000	31,000,000	
	5	.33	380,000,000	3,000,000	170,000,000 L. A. 30,000,000	65,000,000	
	6	.60					Sour and cheesy.

[a] Gelatin.
[b] Or acid.
[c] Probably some acid colonies.
[d] Or alkali.
[e] Sample held in hotel refrigerator.

TABLE XI.—*Raw and pasteurized milk in New York City, examined February and March, 1909—Daily acidity, total bacterial counts, and group percentages—Milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
213	0	0.19	55,300	53,000	3,000	70,000	
	1	.19	14,000	0	14,000	3,000	0 in 1,000 dilutions.
	2	.18	120,000	10,000	[a] 200,000		
	3	.19	[b] 14,000,000	4,000,000	3,000,000	7,000,000	
	4	.24	220,000,000	1,000,000	170,000,000 L. A. 26,000,000	16,000,000	
	5	.37	....	....	....	....	
	6	......	....	....	....	....	
	7	......	....	....	....	....	
	8	1.05	....	....	....	....	Coagulated.
215	0	.18	12,800	1,000	11,000	6,000	
	1	.20	24,000	22,000	3,000	15,000	
	2	.18	4,000,000	800,000	400,000	1,500,000	
	3	.20	39,300,000	4,000,000	14,000,000 L. A. 6,000,000	9,000,000	
	4	.34	....	....	....	....	
	5	......	....	....	....	....	
	6	......	....	....	....	....	
	7	1.05	....	....	....	....	Do.
217	0	.19	6,900	400	L. A. 1,500	4,000	
	1	.19	6,000	4,000	2,000	8,000	
	2	.19	12,300,000	1,000,000	400,000 L. A. 500,000	12,000,000	
	3	.21	205,000,000	1,000,000	115,000,000 L. A. 30,000,000	17,000,000	
	4	......	....	....	....	....	
	5	......	....	....	....	....	
	6	.95	....	....	....	....	Do.
219	0	.19	13,700	300	900	12,900	
	1	.19	54,000	14,000	L. A. 3,000	70,000	
	2	.20	1,780,000	100,000	600,000	1,000,000	
	3	......	....	....	....	....	
	4	......	....	....	....	....	
	5	.71	....	....	....	....	Sour.
221	0	.19	18,850	300	10,600	15,700	
	1	.19	845,000	110,000	10,000	1,050,000	
	2	......	....	....	....	....	
	3	......	....	....	....	....	
	4	.50	....	....	....	....	Slightly sour.
225	0	.18	465,000	1,000	340,000	190,000	No. 225-235, inclusive, from dairy K, pasteurized "flash" process, 71.1° C. (160° F.).
	1	.18	490,000	0	370,000	70,000	
	2	.18	1,160,000	300,000	700,000 L. A. 100,000	500,000	
	3	.24	22,600,000	4,000,000	4,000,000	16,000,000	Old taste, probably; would not be used.
	4	.27	129,000,000	4,000,000	69,000,000 L. A. 4,000,000	37,000,000	
	5	......	....	....	....	....	
	6	.72	1,140,000,000	0	830,000,000	50,000,000	Sour.
	7	.81	....	....	....	....	Do.
	8	.99	....	....	....	....	Smooth curd.
227	0	.20	7,400	1,300	2,100	18,100	
	1	.21	31,000	10,000	18,000	40,000	
	2	.20	4,910,000	700,000	500,000	1,100,000	
	3	.27	....	....	....	....	Old taste; would not be used.
	4	......	....	....	....	....	
229	0	.20	15,000	800	1,100	15,000	
	1	.20	160,000	6,000	105,000	9,000	
	2	.20	14,000,000	3,000,000	2,000,000	10,000,000	
	3	......	....	....	....	....	
	4	.59	....	....	....	....	Sour.

[a] Acid or alkali.

[b] Gelatin.

TABLE XI.—*Raw and pasteurized milk in New York City, examined February and March, 1909—Daily acidity, total bacterial counts, and group percentages—Milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
231	0	0.20	18,000	500	6,600 L. A. 200	18,000	
	1	.19	140,000				Gelatin; liquefied.
	2						
	3	.24	177,000,000	1,000,000	81,000,000 L. A. 4,000,000	34,000,000	Old taste; would not be used.
	4	.37					Sour.
	5	.76					
	6	.87					Curdled.
233	0	.20	15,600	800	11,200 L. A. 500	24,200	
	1	.19	50,000				
	2						
	3	.26	255,000,000	1,100,000	116,000,000 4,000,000	30,000,000	Old taste.
	4	.53					Sour.
	5	.86					Curdled (smooth).
235	0	.22	14,000	1,400	2,800	12,800	
	1						
	2	.21	3,490,000	400,000	100,000	1,900,000	
	3	.20	54,000,000	600,000	300,000	2,400,000	
	4	.37					
	5	.81					Curdled.
237	0	.21	23,700	300	10,000	6,200	Nos. 237–245, inclusive, from dairy M, pasteurized "flash" process, 70° C. (158° F.).
	1	.19	1,500,000	90,000	650,000	870,000	
	2	.19	13,150,000	200,000	7,400,000	2,400,000	
	3	.26					Old taste (might be used).
	4	.35					Slightly sour.
	5						
	6	.83					
239	0	.18	36,400	21,000	3,000	1,400	
	1	.18	15,140,000	4,000,000	100,000	8,300,000	
	2	.20	4,900,000	240,000	5,300,000	300,000	
	3	.20	107,000,000	8,000,000	30,000,000	14,000,000	
	4						
	5	.69					Sour.
	6	.90					
	7	1.0					
	8	1.2					Partly curdled.
241	0	.19	17,400	900	2,900	9,600	
	1	.19	2,500,000	130,000	60,000	760,000	
	2						
	3	.24	167,000,000	19,000,000	64,000,000	26,000,000	Old, cheesy; would not be used.
	4	.62					Slightly sour.
	5	.79					Sour.
243	0	.19	7,300	1,200	0	5,500	0 in 100 dilutions.
	1	.20	470,000	10,000	L. A. 10,000	140,000	
	2	.21	5,600,000	500,000	300,000	1,600,000	
	3	.20	81,000,000	2,000,000	22,000,000 L. A. 2,000,000	36,000,000	Old taste.
	4	.37					Slightly sour.
245	0	.18	12,400	3,800	200	4,000	
	1	.18					
	2	.20	2,700,000	0	300,000	2,700,000	
	3	.20	28,600,000	8,000,000	14,000,000	17,000,000	
	4	.25	62,000,000	11,000,000	7,000,000	20,000,000	Slightly sour; would not be used.
	5						
	6	.52					

TABLE XI.—*Raw and pasteurized milk in New York City, examined February and March, 1909—Daily acidity, total bacterial counts, and group percentages—Milk held at 10° C. (50° F.)*—Continued.

CERTIFIED RAW MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
251	0	0.18	100	0	0	300	From dairy H, No. 251.
	1	.18	200	......	......	......	
	2	.18	3,000	1,000	0	1,000	
	3	.18	13,800,000	400,000	0	16,700,000	
	4	.18	13,000,000	3,000,000	0	12,000,000	
	5	.18	35,000,000	2,400,000	0	22,300,000	
	6	......	......	......	......	......	
	7	.23	77,000,000	9,000,000	3,000,000	41,000,000	Putrid taste and odor; would not use.
	8	.32	......	......	......	......	Strong putrid odor.
	9	.54	......	......	......	......	Strong putrid odor; sour.
	10	.73	......	......	......	......	

RAW MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
253	0	0.19	288,000	7,000	125.000	16,000	Raw milk, dairy P, Nos. 253 and 261.
	1	.20	3,000,000	60,000	1,310,000 L. A. 30,000	40,000	
	2	.19	6,000,000	4,000,000	0	2,000,000	
	3	......	......	......	......	......	
	4	.19	42,000,000	3,000,000	9,000,000	3,000,000	Old taste.
	5	.31	......	......	......	......	Slightly sour; would not use.
	6	.45	......	......	......	......	Sour, thickened.
261	0	.18	44,500	1,100	34,000	9,000	
	1	.18	580,000	0	470,000 L. A. 40,000	120,000	
	2	.18	10,200,000	1,200,000	1,200,000 L. A. 700,000	1,200,000	
	3	.18	106,000,000	7,000,000	35,000,000 L. A. 2,000,000	17,000,000	
	4	.21	294.000,000	15,000,000	63,000,000	44,000,000	Sweet.
	5	......	......	......	......	......	
	6	.47	......	......	......	......	Sour.
255	0	.18	101,000	12,000	11,000	9,000	From dairy N, Nos. 255–259, inclusive.
	1	.18	560,000	30,000	30,000	70,000	
	2	.20	6,000,000	1,300,000	400,000	3,400,000	
	3	.19	210,000,000	5,000,000	90,000,000	51,000,000	Old taste.
	4	......	......	......	......	......	
	5	.30	160,000,000	22,000,000	54,000,000 L. A. 2,000,000	47,000,000	Artificial sweet taste.
	6	.42	......	......	......	......	Slightly sour, old taste; would not be used.
	7	.57	......	......	......	......	Sour.
	8	.72	......	......	......	......	Partly curdled.
257	0	.18	261,000	30,000	80,000	60,000	
	1	.19	140,000	20,000	150,000	30,000	
	2	.18	5,400,000	2,700,000	100,000	2,700,000	
	3	......	......	......	......	......	
	4	.18	103,000,000	15,000,000	7,000,000	38,000,000	Slightly old taste.
	5	.18	121,000,000	28,000,000	11,000,000	47,000,000	Nutty flavor; might be used.
	6	.18	......	......	......	......	Slightly putrid smell.
	7	.31	......	......	......	......	Slightly sour.
	8	.53	......	......	......	......	Sour.
	9	.64	......	......	......	......	Curdled, whey.
259	0	.18	548,000	50,000	500,000 L. A. 10,000	20,000	
	1	.18	4,500,000	1,300,000	300,000 L. A. 400,000	2,000,000	
	2	......	......	......	......	......	
	3	.18	58,500,000	2,000,000	10,600,000 L. A. 600,000	8,700,000	

TABLE XI.—*Raw and pasteurized milk in New York City, examined February and March, 1909—Daily acidity, total bacterial counts, and group percentages—Milk held at 10° C. (50° F.)*—Continued.

RAW MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
259	4	0.18	149,000,000	18,000,000	55,000,000	41,000,000	Old taste; might be used.
	5	.26					Slightly sour; slightly putrid taste.
	6	.38					Sour.
	7	.54					
	8	.64					
263	0	.18	21,300,000	2,800,000	500,000	17,800,000	Nos. 263–269, inclusive, from stores.
	1	.18	90,000,000	8,000,000	29,000,000 L. A. 7,000,000	58,000,000	
	2	.18	179,000,000	17,000,000	45,000,000 L. A. 8,000,000	89,000,000	
	3	.35	318,000,000	9,000,000	134,000,000 L. A. 9,000,000	77,000,000	Sour; would not be used.
	4						
	5	.57					Sour.
265	0	.18	348,000	13,000	278,000	24,000	
	1	.18	1,040,000	170,000	260,000	300,000	
	2	.18	17,700,000	3,600,000	1,000,000	2,900,000	
	3	.18	101,000,000	23,000,000	3,000,000 L. A. 1,000,000	13,000,000	
	4	.20	102,000,000	25,000,000	10,000,000 L. A. 10,000,000	34,000,000	Old taste; would not be used.
	5	.26	312,000,000	30,000			Old taste.
	6						
	7	.54					Sour.
267	0	.17	61,000	2,000	17,000	21,000	
	1	.18	500,000	80,000	100,000 L. A. 60,000	190,000	
	2	.18	9,500,000	2,300,000	300,000	4,500,000	
	3	.18	80,000,000	15,000,000	10,000,000	14,000,000	Might be used; slightly off taste; part of plate liquefied.
	4						
	5	.32					Slightly sour; bitter taste.
269	0	.18	131,000	22,000	31,000	14,000	
	1	.18	1,500,000	100,000	500,000	800,000	
	2	.18	130,000,000	12,000,000	33,000,000	34,000,000	
	3						
	4	.31					Slightly sour; would not be used.

TABLE XII.—*Raw and pasteurized milk in New York City—Milk held at room temperature, 20° C. (68° F.).*

PASTEURIZED MILK.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
202	0	0.22	[a] 8,600	300	[b] 4,100	[illegible],200	From dairy H, Nos. 202–220, inclusive.
	1	.22	[a] 2,850,000	270,000	[b] 20,000	2,560,000	
	2	.38	[a] 417,000,000	7,000,000	210,000,000	[c] 200,000,000	Slightly sour.
	3	.99					Curdled; smooth.

[a] Gelatin.
[b] Or L. A.
[c] Or acid.

TABLE XII.—*Raw and pasteurized milk in New York City—Milk held at room temperature, 20° C. (68° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
204	0	0.21	[a]20,600	600	[b]2,000	18,000	
	1	.21	[a]4,300,000	400,000	[b]600,000	3,300,000	
	2	.68	......	......	......	......	Sour.
	3	.97	......	......	......	......	Curdled.
206	0	.19	[a]32,200	1,200	5,000	26,000	
	1	.18	[a]15,500,000	1,300,000	8,700,000	5,500,000	
	2	......	......	......	......	......	
	3	.98	[a]521,000,000	7,000,000	400,000,000	114,000,000	Curdled; gas; sweet-smelling curd.
208	0	.18	5,700	200	[b]1,000	7,500	
	1	......	......	......	......	......	
	2	.53	320,000,000	6,000,000	104,000,000 L. A. 23,000,000	68,000,000	Sour; would not be used.
	3	......	......	......	......	......	
	4	.99	780,000,000	1,000,000	360,000,000	24,000,000	Curdled; smooth.
212	0	.21	6,400	500	13,500	15,000	
	1	......	......	......	......	......	Low temperature over Sunday.
	2	.60	430,000,000	10,000,000	300,000,000	90,000,000	Sour; would not be used.
	3	.84	......	......	......	......	
214	0	.19	[a]14,800	200	[b]300	14,300	
	1	.19	1,120,000	140,000	150,000	500,000	Temperature low at night.
	2	.30	200,000,000	4,000,000	190,000,000 L. A. 30,000,000	30,000,000	
	3	.85	......	......	......	......	Curdled; smooth.
216	0	.19	10,200	300	3,000	4,000	
	1	.19	1,140,000	300,000	100,000	500,000	Temperature low at night.
	2	.26	200,000,000	3,000,000	240,000,000 L. A. 39,000,000	30,000,000	
	3	.92	......	......	......	......	Curdled; smooth.
218	0	19	7,900	600	[b]3,800	8,800	
	1	.18	1,000,000	300,000	400,000	700,000	
	2	.56	......	......	......	......	Sour.
220	0	.19	11,100	400	1,600	22,300	
	1	.19	3,450,000	1,500,000	[b]1,200,000	13,600,000	
	2	.93	......	......	......	......	Sour; smooth curd.
[c]224	0	......	......	......	......	......	From dairy K; pasteurized 71.1° C. (160° F.) "flash" process, Nos. 224–236, inclusive.
	1	.45	588,000,000	1,000,000	570,000,000	......	Plate acid; slightly sour.
	2	1.01	......	......	......	......	Curdled.
226	0	.18	370,000	3,000	540,000	......	Plate acid.
	1	.19	5,000,000	400,000	2,700,000 L. A. 1,100,000	2,500,000	
	2	.81	......	......	......	......	Sour; curdled in afternoon.
228	0	.20	10,200	500	[b]1,900	28,000	
	1	.20	11,400,000	100,000	4,400,000 L. A. 900,000	500,000	
	2	.80	......	......	......	......	Curdled; gas.
230	0	.20	8,300	500	1,100 L. A. 300	30,500	
	1	[d].19 [e].24	13,500,000	100,000	5,800 000	1,600,000	Slightly sour.
	2	.86	......	......	......	......	Sour; curdled.

[a] Gelatin. [b] Or L. A. [c] Held in hotel room. [d] 9 a. m. [e] 3 p. m.

TABLE XII.—*Raw and pasteurized milk in New York City—Milk held at room temperature 20° C. (68° F.)*—Continued.

PASTEURIZED MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
236	0	0.22	13,600	3,000	1,100	11,500	
	1						Temperature low.
	2	.31					Slightly sour; would not be used.
	3	.90					Curdled.
238	0	.18	18,400	2,000	9,000	4,000	Dairy M, Nos. 238-246, inclusive; pasteur) ized 70° C. (158° F.- "flash" process.
	1	[a] .20	87,000,000	300,000	23,600,000	11,200,000	
		[b] .27					Slightly sour; would not be used.
	2	.79					Sour.
240	0	.18	15,000	900	400	4,100	
	1	.18	23,400,000	400,000	600,000	8,600,000	
	2	.27					Slightly sour; would not be used.
242	0	.19	60,900	1,100	1,800	4,700	
	1	.22	540,000,000	3,000,000	17,000,000 L. A. 5,000,000	48,000,000	Slightly sour or old taste; would not be used.
	2						
	3	1.12					Curdled; gas.
244	0	.19	37,600	5,500	400	14,300	
	1	[a] .20	17,000,000	4,900,000	400,000	11,500,000	
		[b] .25					Old taste.
	2	.79					Smooth curd; sour.
246	0	.18	7,000	1,100	300	2,300	
	1	.18	27,400,000	500,000	3,600,000	8,600,000	
	2	.84					Curdled; sour.
CERTIFIED RAW MILK.							
252	0	0.18	500	0	0	200	From dairy H, No, 252.
	1	.19	22,000	0	0	10,000	
	2	.18	55,000,000	14,000,000	3,000,000	6,000,000	
	3	.69	840,000,000	14,000,000	317,000,000	150,000,000	Partly coagulated.
RAW MILK.							
254	0	0.19	420,000	20,000	130,000	50,000	From dairy P, Nos. 254 and 262.
	1	[a] .20	60,000,000	7,000,000	17,000,000 L A. 3,000,000	13,000,000	Slightly off taste.
		[b] .27					Slightly sour.
	2	.73	1,044,000,000	50,000,000	160,000,000	50,000,000	Not curdled, but sour.
	3						
	4	1.10					Curdled; smooth curd.
262	0	.18	46,800	5,200	18,900	20,000	
	1	.23	324,000,000	0	205,000,000 L. A. 1,000,000	12,000,000	Would not be used.
	2	.72					Curdled; sour; smooth
256	0	.18	81,000	15,000	19,000	11,000	From dairy N, Nos. 256-262.
	1	.36	624,000,000	9,000,000	33,000,000 L. A. 7,000,000	60,000,000	Would not be used.
	2	.90					Curdled.
258	0	.18	284,000	40,000	60,000	40,000	
	1	.18	18,000,000	3,200,000	4,500,000 L. A. 500,000	6,500,000	Very slightly sour; might use.
	2	.72					Curdled; gas.

[a] 9 a. m. [b] 3 p. m.

TABLE XII.—*Raw and pasteurized milk in New York City—Milk held at room temperature, 20° C. (68° F.)*—Continued.

RAW MILK—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose agar.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
260	0	0.18	376,000	22,000	190,000	28,000	
	1	.61	1,300,000,000	2,000,000	94,000,000	13,000,000	Part coagulated temperature 750-80° F.
264	0	.18	22,700,000	2,700,000	1,200,000	13,900,000	From stores, Nos. 264-270.
	1	.41	....	....	....	....	Sour; would not be used.
266	0	.18	280,000	7,000	205,000	58,000	
	1	[a].18	77,000,000	17,000,000	36,000,000	17,000,000	
		[b].20	....	....	....	....	Slightly sour; might be used.
	2	.62	....	....	....	....	
268	0	.17	46,000	2,000	6,000	10,000	
	1	.18	110,000,000	6,000,000	8,000,000	18,000,000	
	2	......	....	....	....	....	Curdled; smooth curd.
270	0	.18	125,000	34,000	30,000	18,000	
	1	.19	284,000,000	15,000,000	84,000,000 L. A. 3,000,000	62,000,000	
	2	.69	....	....	....	....	Do.

[a] 9 a. m.

[b] 3 p. m.

TABLE XIII.—*Raw and pasteurized milk in New York City—Daily total bacterial counts and group percentages—Milk held at 10° C. (50° F.).*

PASTEURIZED MILK—DAIRY H.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
201...	0	11,200	5.35	57.14	37.5
	1	42,000	2.36	2.36	94.7
	2	882,000	5.66	.22	94.1
	3	7,900,000	20.2	....	97.7
	4	....	....	....	......
	5	47,100,000	4.24	71.12	24.63
	6	457,000,000	3.28	87.52	9.19
	7	575,000,000	.34	93.90	5.56
203...	0	10,000	....	10.00	90.00
	1	50,000	....	....	100.00
	2	4,000,000	22.50	77.5	......
	3	....	....	....	......
	4	20,600,000	5.09	49.07	45.83
	5	....	....	....	......
	6	403,000,000	.74	86.84	12.40
	7	331,000,000	.60	79.40	19.90
205...	0	29,800	2.01	9 86	87.87
	1	59,000	1.69	8.47	89.83
	2	....	....	....	......
	3	1,300,000	7.69	15.3	76.92
	4	26,800,000	3.35	22.38	74.33
	5	69,000,000	8.69	40.57	50.72
	6	206,000,000	1.94	74.27	23.78
207...	0	9,800	2.04	10.20	87.75
	1	....	....	....	......
	2	309,000	4.53	8.09	87.37
	3	....	....	....	......
	4	14,100,000	9.21	21.27	69.50
	5	53,000,000	13.20	37.73	49.05
	6	189,000,000	1.05	70.37	28.57
209...	0	....	....	....	......
	1	9,200	9.78	13.04	77.17
	2	....	....	....	......
209...	3	4,290,000	3.96	27.97	69.93
	4	19,600,000	5.10	4.59	90.30
	5	64,000,000	6.25	34.37	59.37
	6	275,000,000	2.90	67.63	29.45
211...	0	21,000	4.76	52.38	42.85
	1	....	....	....	......
	2	2,060,000	13.10	4.36	82.52
	3	15,900,000	6.28	2.51	91.19
	4	60,000,000	5.00	43.33	51.66
	5	268,000,000	1.11	74.62	24.25
213...	0	126,000	42.06	2.38	55.55
	1	17,000	....	82.35	17.64
	2	210,000	4.76	95.23	......
	3	14,000,000	28.57	21.42	50.00
	4	213,000,000	.46	92.01	7.51
215...	0	18,000	5.55	61.11	33.33
	1	40,000	55.00	7.50	37.50
	2	2,700,000	29.62	14.81	55.55
	3	33,000,000	12.12	60.60	27.27
217...	0	5,900	6.77	25.42	67.79
	1	14,000	28.42	14.28	57.14
	2	3,100,000	32.25	29.03	38.71
	3	163,000,000	.61	88.95	10.42
219...	0	14,100	2.12	6.38	91.48
	1	87,000	16.09	3.44	80.45
	2	1,700,000	5.88	35.29	58.82
221...	0	26,600	1.12	39.84	59.02
	1	1,170,000	9.40	.85	89.74

TABLE XIII.—*Raw and pasteurized milk in New York City—Daily total bacterial counts and group percentages—Milk held at 10° C. (50° F.)*—Continued.

PASTEURIZED MILK—DAIRIES K AND M.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
225...	0	531,000	0.18	64.03	35.78
	1	440,000	(a)	84.09	15.90
	2	1,600,000	18.75	50.00	31.25
	3	24,000,000	16.66	16.66	66.66
	4	114,000,000	3.50	64.03	32.45
	5	....	....	....	....
	6	880,000,000	(b)	94.31	5.68
227...	0	31,500	6.04	9.76	84.18
	1	68,000	14.70	26.47	58.82
	2	2,300,000	30.43	21.73	47.82
229...	0	34,000	23.52	32.35	44.11
	1	120,000	5.00	87.50	7.5
	2	15,000,000	20.00	13.33	66.66
231...	0	25,300	1.97	26.83	71.14
	1	....	....	....	....
	2	....	....	....	....
	3	120,000,000	.83	70.83	28.33
233...	0	36,700	2.17	31.88	65.94
	1	....	....	....	....
	2	....	....	....	....
	3	151,000,000	.72	79.41	19.85
235...	0	17,000	8.23	16.47	75.29
	1	....	....	....	....
235...	2	2,400,000	16.66	4.16	79.16
	3	3,300,000	18.18	9.09	72.72
237...	0	16,500	1.81	60.60	37.52
	1	1,610,000	5.59	40.37	54.03
	2	10,000,000	2.00	74.00	24.00
239...	0	25,400	82.67	11.80	5.11
	1	12,400,000	32.25	.80	66.92
	2	5,840,000	4.10	90.75	51.36
	3	52,000,000	15.38	57.69	26.92
241...	0	13,400	6.71	21.64	71.64
	1	950,000	13.68	6.31	80.00
	2	....	....	....	....
	3	109,000,000	17.43	58.71	23.75
243...	0	6,700	17.91	....	82.09
	1	160,000	6.25	6.25	87.50
	2	2,400,000	20.83	12.50	66.66
	3	62,000,000	3.22	38.70	58.06
245...	0	8,000	47.50	2.50	50.00
	1	....	....	....	....
	2	3,000,000	....	10.00	90.00
	3	39,000,000	20.51	35.89	43.58
	4	38,000,000	28.94	18.42	52.63

CERTIFIED MILK.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
251...	0	300	....	....	100.00
	1	....	....	....	....
	2	2,000	50.00	....	50.00
	3	17,100,000	2.33	....	97.66
251...	4	15,000,000	20.00	....	80.00
	5	24,700,000	9.71	....	90.28
	6	....	....	....	....
	7	53,000,000	16.98	5.66	77.35

RAW MILK.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
253...	0	148,000	4.72	84.45	10.81
	1	1,440,000	4.16	93.05	2.77
	2	6,000,000	66.66	....	33.33
	3	....	....	....	....
	4	15,000,000	20.00	60.00	20.00
261...	0	44,100	2.49	77.09	20.40
	1	630,000	....	80.95	19.04
	2	4,300,000	27.90	44.18	27.90
	3	61,000,000	11.47	60.65	27.86
	4	122,000,000	12.29	51.63	36.06
255...	0	32,000	37.50	34.37	28.12
	1	130,000	23.07	23.07	53.84
	2	5,100,000	25.49	7.84	66.66
	3	146,000,000	3.42	61.64	34.93
	4	....	....	....	....
	5	125,000,000	17.60	44.80	37.50
257...	0	170,000	17.64	47.05	35.29
	1	200,000	10.00	75.00	15.00
	2	5,550,000	49.09	1.81	49.09
	3	....	....	....	....
	4	60,000,000	25.00	11.66	63.33
	5	86,000,000	32.55	12.79	54.65
259...	0	580,000	8.62	87.93	3.44
	1	4,000,000	32.50	17.50	50.00
	2	....	....	....	....
	3	21,900,000	9.13	51.14	39.72
	4	114,000,000	15.78	48.24	35.96
263...	0	21,100,000	13.27	2.36	84.36
	1	102,000,000	7.84	35.29	56.86
	2	159,000,000	10.69	33.33	55.97
	3	229,000,000	3.93	62.44	33.62
265...	0	315,000	4.12	88.25	7.61
	1	730,000	23.28	35.61	41.09
	2	7,500,000	48.00	13.33	38.66
	3	40,000,000	57.50	10.00	32.50
	4	79,000,000	31.64	25.31	43.03
267...	0	40,000	5.00	42.50	52.50
	1	430,000	18.60	37.20	44.18
	2	7,100,000	32.39	4.22	63.38
	3	39,000,000	38.46	25.64	35.89
269...	0	67,000	32.83	46.26	20.89
	1	1,400,000	7.14	35.71	57.14
	2	79,000,000	15.18	41.77	43.03

[a] 0 in 10,000 dilutions.

[b] 0 in 100,000 dilutions.

TABLE XIV.—*Raw and pasteurized milk at New York City—Total daily bacterial counts and group percentages—Milk held at room temperature, 20° C. (68° F.).*

PASTEURIZED MILK—DAIRY H.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
202...	0	8,600	3.48	47.67	48.83
	1	2,850,000	9.47	.70	89.82
	2	417,000,000	1.67	50.35	47.96
204...	0	20,600	2.91	9.70	87.37
	1	4,300,000	9.30	13.95	76.74
206...	0	32,200	3.72	15.52	80.75
	1	15,500,000	8.38	56.17	35.48
208...	0	8,700	2.29	11.49	86.20
	1	....	....	....	......
	2	201,000,000	2.98	63.18	33.83
212...	0	29,000	1.72	46.55	51.72
	1	....	....	....	......
	2	400,000,000	2.50	75.00	22.50
214...	0	14,800	1.35	2.02	96.62
	1	790,000	17.72	18.98	63.29
	2	254,000,000	1.57	86.61	11.81
216...	0	7,300	4.10	41.09	54.79
	1	900,000	33.33	11.11	55.55
	2	312,000,000	.96	89.42	9.61
218...	0	132,000	4.54	28.78	66.66
	1	1,400,000	21.42	28.57	50.00
220...	0	24,300	1.64	6.58	91.76
	1	16,300,000	9.20	7.36	83.43

PASTEURIZED MILK—DAIRIES K AND M.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
224...	0	....	....	....	......
	1	571,000,000	0.17	99.82	......
226...	0	543,000	.55	99.44	......
	1	6,700,000	5.97	56.71	37.31
228...	0	5,200	9.61	36.53	53.84
	1	15,900,000	1.69	89.83	8.47
230...	0	32,400	1.54	4.32	94.13
	1	7,500,000	1.33	77.33	21.33
236...	0	15,600	19.23	7.05	73.71
238...	0	15,000	13.33	60.00	26.66
	1	35,100,000	.85	67.23	31.90
240...	0	5,400	16.66	7.40	75.92
	1	9,600,000	4.16	6.25	89.58
242...	0	7,600	14.47	23.68	61.84
	1	73,000,000	4.10	30.13	65.75
244...	0	20,200	27.22	1.98	70.79
	1	16,800,000	29.16	2.38	68.45
246...	0	3,700	29.72	8.10	62.16
	1	12,700,000	3.93	28.34	67.71

CERTIFIED RAW MILK.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
252...	0	200	....	....	100.00
	1	10,000	....	....	100.00
252...	2	23,000,000	60.86	13.04	26.08
	3	481,000,000	2.91	65.90	31.18

RAW MILK.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
254...	0	200,000	10.00	65.00	25.00
	1	40,000,000	17.50	50.00	32.50
	2	260,000,000	19.23	61.53	19.23
262...	0	44,000	11.79	42.85	45.35
	1	218,000,000	....	94.49	5.50
256...	0	45,000	33.33	42.22	24.44
	1	109,000,000	8.25	36.69	55.04
258...	0	140,000	28.57	42.85	28.57
	1	14,700,000	21.76	34.01	44.21
260...	0	240,000	9.16	79.16	11.66
	1	24,400,000	8.19	38.52	53.27
264...	0	17,800,000	15.16	6.74	78.08
266...	0	270,000	2.59	75.92	21.48
	1	70,000,000	24.28	51.42	24.28
268...	0	18,000	11.11	33.33	55.55
	1	32,000,000	18.75	25.00	56.25
270...	0	82,000	41.46	36.58	21.94
	1	164,000,000	9.14	53.04	37.80

TABLE XV.—*Raw milk at Washington, D. C., examined in January, 1909—Daily acidity and total and group counts of bacteria—Milk held at 10° C. (50° F.).*

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose gelatin.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
324	0	0.18	85,000	9,000	26,000	50,000	Raw milk from dairy T.
	1	.23	30,800,000	1,500,000	9,900,000	19,400,000	
	2	.19	28,800,000	5,900,000	3,800,000	19,100,000	Temperature down to 4° C. (40° F.).
	3	.19	114,000,000	23,000,000	13,000,000	78,000,000	
	4	.24	108,000,000	19,000,000	22,000,000	67,000,000	Temperature low.
	5	.25	76,000,000	11,000,000	3,000,000	62,000,000	Old taste.
	6						
	7	.53	436,000,000	60,000,000	147,000,000	229,000,000	
325	0	.16	43,400	10,000	13,900	19,500	
	1	.18	660,000	50,000	280,000	330,000	
	2	.16	1,590,000	430,000	150,000	1,010,000	
	3	.17	5,500,000	2,700,000	300,000	2,500,000	
	4	.18	24,000,000	3,700,000	1,300,000	19,000,000	Do.
	5						
	6	.63	475,000,000	67,000,000	200,000,000	208,000,000	Sour; strong old flavor.
326	0	.18	30,700	2,100	8,100	20,500	
	1	.16	400,000	110,000	50,000	240,000	
	2	.16	840,000	310,000	40,000	490,000	
	3	.16	910,000	350,000	30,000	530,000	
	4						
	5	.38	241,000,000	53,000,000	16,000,000	172,000,000	Old taste; might be used.
	6	.58	563,000,000	32,000,000	394,000,000	137,000,000	Old taste; sour; putrid.
	7	.69					
327	0	.16	149,000	34,000	44,000	71,000	
	1	.16	260,000	65,000	31,000	164,000	
	2	.18	19,000,000	3,800,000	300,000	14,900,000	
	3						
	4	.40	411,000,000	90,000,000	200,000,000	121,000,000	Old taste.
	5	.65	1,220,000,000	60,000,000	730,000,000	430,000,000	Old taste; sour; would not be used.
	6	.73					Curdled.
328	0	.14	126,000	34.000	55,000	37,000	
	1	.16	17,900,000	5,800,000	4,900,000	7,200,000	
	2						
	3	.52	508,000,000	140,000,000	262,000,000	106,000,000	Very slightly sour; would be used by many.
	4	.72					Curdled.
329	0	.16	14,200	3,300	3,700	7,200	
	1						
	2	.22	116,000,000	36,000,000	20,000,000	60,000,000	
	3	.29	240,000,000	9,000,000	192,000,000	39,000,000	
	4	.45	404,000,000	75,000,000	207,000,000	122,000,000	Old taste; slightly sour.
	5	.56					Sour; not curdled.
	6	.68					Old, putrid taste; sour.
330	0	.16	125,000	23,000	37,000	65,000	
	1	.16	9,500,000	2,800,000	1,500,000	5,200,000	
	2	.16	45,000,000	6,700,000	10,600,000	277,000	Old taste.
	3	.20	213,000,000	50,000,000	47,000,000	116,000,000	Old taste; cheesy.
	4	.40	820,000,000	140,000,000	330,000,000	350,000,000	Old taste; would not be used.
	5	.61					Sharp old taste; sour.
331	0	.15	523,000	35,000	275,000	213,000	
	1	.16	8,900,000	2,800,000	1,500,000	4,600,000	
	2	.15	79,000,000	14,000,000	27,000,000	38,000,000	
	3	.25	84,000,000	13,000,000	38,000,000	33,000,000	Slightly old taste.
	4	.36	226,000,000	53,000,000	56,000,000	117,000,000	Old taste; sweetish.
	5						
	6	.66					Putrid; sour.
332	0	.16	627,000	159,000	148,000	320,000	
	1	.16	21,000,000	2,300,000	9,100,000	9,600,000	
	2	.21	92,000,000	19,000,000	32,000,000	41,000,000	Slightly old taste.
	3	.30	184,000,000	31,000,000	75,000,000	78,000,000	Do.
	4						
	5	.63					Bitter; sour.

TABLE XV.—*Raw milk at Washington, D. C., examined in January, 1909—Daily acidity and total and group counts of bacteria—Milk held at 10° C. (50° F.)*—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose gelatin.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
333	0	0.15	172,000	15,000	58,000	99,000	
	1	.17	7,000,000	2,300,000	600,000	4,100,000	
	2	.18	53,000,000	13,000,000	9,000,000	31,000,000	
	3	......	....	....	....	....	
	4	.44	860,000,000	220,000,000	180,000,000	460,000,000	Old taste; would not be used.
	5	.63	690,000,000	100,000,000	230,000,000	360,000,000	Old taste; bitter; slightly sour.
	6	.74	....	....	....	....	Old taste; sour.
334	0	.14	464,000	450,000	2,000	12,000	
	1	.18	11,000,000	4,500,000	500,000	6,000,000	
	2	......	....	....	....	....	
	3	.27	123,000,000	68,000,000	8,000,000	47,000,000	Old taste.
	4	.37	167,000,000	76,000,000	14,000,000	77,000,000	Do.
	5	.54	....	....	....	....	Sour; bitter.
335	0	.16	324,000	46,000	40,000	238,000	
	1	......	....	....	....	....	
	2	.18	123,000,000	22,000,000	25,000,000	76,000,000	
	3	.30	194,000,000	30,000,000	74,000,000	90,000,000	
	4	.41	150,000,000	26,000,000	62,000,000	62,000,000	Old taste.
	5	.58	....	....	....	....	Bitter; sour.
	6	.63	....	....	....	....	Sour; old.
336	0	.16	243,000	40,000	75,000	128,000	
	1	.16	3,810,000	670,000	1,170,000	1,970,000	
	2	.18	47,900,000	5,500,000	7,700,000	34,700,000	
	3	.21	190,000,000	30,000,000	80,000,000	80,000,000	Slightly old taste.
	4	.37	182,000,000	33,000,000	43,000,000	106,000,000	Slightly old taste; slightly putrid.
	5	......	....	....	....	....	
	6	.65	....	....	....	....	Strong, old taste; curdled.
337	0	.16	146,000	25,000	27,000	94,000	
	1	.17	7,030,000	1,230,000	40,000	5,760,000	Acid count probably low.
	2	.18	120,000 000	40,000,000	20,000,000	60,000,000	
	3	.22	167,000,000	26,000,000	46,000,000	95,000,000	
	4	......	....	....	....	....	
	5	.64	....	....	....	....	Strong, old taste; sour.
338	0	.17	36,000	5,200	9,400	21,400	
	1	.16	3,700,000	1,000,000	400,000	2,300,000	
	2	.19	37,000,000	15,000,000	6,000,000	16,000,000	
	3	......	....	....	....	....	
	4	.38	306,000,000	31,000,000	161,000,000	114,000,000	Old taste.
	5	.63	....	....	....	....	Sour.
339	0	.16	78,000	18,000	27,000	33,000	
	1	.18	3,210,000	600,000	920,000	1,690,000	
	2	......	....	....	....	....	
	3	.31	143,000,000	9,000,000	49,000,000	85,000,000	Old taste.
	4	.58	564,000,000	40,000,000	305,000,000	219,000,000	Bitter.
	5	.65	....	....	....	....	Sour.
340	0	.16	1,190,000	90,000	670,000	430,000	
	1	......	....	....	....	....	
	2	.24	152,000,000	11,000,000	59,000,000	82,000 000	Very slightly old taste.
	3	.43	335,000,000	14,000,000	229,000,000	92,000,000	Slightly sour.
	4	.65	....	....	....	....	Sour.
341	0	.19	4,400	1,500	600	2,300	Raw milk from dairy S.
	1	.21	50,000	15,000	....	35,000	
	2	.21	31,200,000	3,000,000	....	28,200,000	
	3	.20	34,000,000	7,000,000	....	27,000,000	
	4	......	200,000,000	60,000,000	....	140,000,000	
	5	.28	140,000,000	44,000,000	8,000,000	88,000,000	
	6	......	....	....	....	....	
	7	.50	410,000,000	150,000,000	70,000,000	190,000,000	Curdled.

Table XV.—*Raw milk at Washington, D. C., examined in January, 1909—Daily acidity and total and group counts of bacteria—Milk held at 10° C. (50° F.)*—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose gelatin.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
342	0	0.19	1,400	800	200	400	
	1	.20	4,000	2,100	900	1,000	
	2	.19	868,000	36,000	......	832,000	
	3	......	36,700,000	3,200,000	......	33,500,000	
	4	.27	81,000,000	5,000,000	......	76,000,000	
	5	......	......	......	......	......	
	6	.43	590,000,000	20,000,000	250,000,000	320,000,000	
	7	.64	......	......	......	......	
343	0	.19	67,000	29,000	4,000	34,000	
	1	......	8,200,000	1,700,000	......	6,500,000	
	2	.21	27,700,000	5,000,000	200,000	22,500,000	
	3	......	......	......	......	......	
	4	.25	292,000,000	14,000,000	111,000,000	167,000,000	
	5	.45	......	......	......	......	
	6	.64	......	......	......	......	
344	0	......	5,400	3,800	600	1,000	
	1	.21	170,000	60,000	......	110,000	
	2	......	......	......	......	......	
	3	.24	122,000,000	14,000,000	1,000,000	107,000,000	
	4	.24	......	......	......	......	
	5	.45	......	......	......	......	

Table XVI.—*Raw milk at Washington, D. C., examined during winter 1909–10—Daily total and group counts of bacteria and daily acidity—Milk held at room temperature, 20° C. (68° F.).*

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose gelatin.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
345	0	0.16	39,000	5,000	10,000	24,000	
	1	.20	140,000,000	60,000,000	20,000,000	60,000,000	
	2	.63	500,000,000	12,000,000	425,000,000	63,000,000	Curdled; not sour to taste.
346	0	.16	246,000	25,000	100,000	121,000	
	1	.22	121,000,000	8,000,000	70,000,000	43,000,000	
	2	.63	654,000,000	54,000,000	429,000,000	171,000,000	Sour; putrid.
347	0	.16	102,000	15,000	17,000	70,000	
	1	.18	69,000,000	11,000,000	5,800,000	52,200,000	
	2	.63	......	......	......	......	Sour; slightly curdled.
348	0	.16	40,800	8,400	16,100	16,300	
	1	.22	73,000,000	4,000,000	51,000,000	18,000,000	
	2	.66	72,000,000	7,000,000	31,000,000	34,000,000	Sour; curdled.
349	0	.16	78,000	12,000	19,000	47,000	
	1	.23	......	......	......	......	
	2	......	......	......	......	......	
	3	.93	......	......	......	......	Curdled.
350	0	.12	34,600	5,500	14,200	14,900	
	1	.25	73,000,000	19,000,000	23,000,000	31,000,000	
	2	.61	86,000,000	8,000,000	49,000,000	29,000,000	
351	0	.17	372,000	21,000	267,000	84,000	
	1	.24	168,000,000	22,000,000	100,000,000	46,000,000	
	2	.72	1,070,000,000	60,000,000	800,000,000	210,000,000	

TABLE XVI.—*Raw milk at Washington, D. C., examined during winter 1909–10—Daily total and group counts of bacteria and daily acidity—Milk held at room temperature, 20° C. (68° F.)*—Continued.

Sample No.	Age of milk in days.	Acidity in percentage of lactic acid.	Total bacteria per c. c. on litmus lactose gelatin.	Peptonizing bacteria per c. c. on litmus lactose gelatin.	Lactic-acid bacteria per c. c. on litmus lactose gelatin.	Alkali formers and inert bacteria per c. c. on litmus lactose gelatin.	Remarks.
352	0	0.15	25,000	11,000	8,000	6,000	
	1	.18	64,000,000	38,000,000	5,000,000	21,000,000	Slightly strong taste.
	2	.61	416,000,000	71,000,000	121,000,000	224,000,000	Putrid.
353	0	.17	19,700	3,000	4,100	12,600	
	1	.20	70,000,000	10,000,000	18,000,000	42,000,000	
	2	.63	349,000,000	49,000,000	130,000,000	170,000,000	Sour; bitter.
354	0	.17	257,000	14,000	164,000	79,000	
	1	.23	94,000,000	18,000,000	10,000,000	66,000,000	Garlic taste.
355	0	.15	111,000	36,000	25,000	50,000	
	1	......	....	....	....	....	
	2	.58	700,000,000	80,000,000	190,000,000	430,000,000	
356	0	.17	6,700	500	2,600	3,600	
	1	.17	14,500,000	60,000,000	16,000,000	69,000,000	
	2	.34	231,000,000	37,000,000	93,000,000	101,000,000	Very slight old taste.
357	0	.16	20,800	1,300	5,300	14,200	
	1	.18	29,200,000	8,400,000	9,100,000	11,700,000	
	2	.52	271,000,000	25,000,000	126,000,000	120,000,000	Slightly old taste.
358	0	.17	18,400	1,500	5,300	11,600	
	1	.17	12,000,000	1,400,000	4,500,000	6,100,000	
	2	.53	790,000,000	80,000,000	440,000,000	270,000,000	Old taste.
359	0	.17	4,600	(a)	2,500	2,100	
	1	.17	88,000,000	29,000,000	11,000,000	48,000,000	
	2	.30	1,220,000,000	150,000,000	520,000,000	550,000,000	Slightly sour.
360	0	.18	22,800	4,000	8,100	10,700	
	1	.18	83,000,000	31,000,000	17,000,000	35,000,000	
	2	.58	1,110,000,000	60,000,000	780,000,000	270,000,000	Sour; old.
361	0	.18	24,900	4,000	5,700	15,200	
	1	.21	123,000,000	24,000,000	31,000,000	68,000,000	Slightly old taste.
	2	.67	1,010,000,000	60,000,000	750,000,000	200,000,000	Curdled.
362	0	.15	130,000	2,000	45,000	83,000	
	1	.24	111,000,000	15,000,000	41,000,000	55,000,000	Old taste.
	2	.67	740,000,000	30,000,000	660,000,000	50,000,000	Curdled.
363	0	.17	281,000	43,000	93,000	145,000	
	1	.34	234,000,000	54,000,000	28,000,000	152,000,000	Old.
	2	.76	139,000,000	30,000,000	48,000,000	61,000,000	Curdled.

[a] 0 in 100 dilution.

TABLE XVII.—*Raw milk at Washington, D. C.—Daily total counts and group percentages of bacteria—Milk held at 10° C. (50° F.).*

RAW MILK—DAIRY T.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
324	0	85,000	10.58	30.58	58.82
	1	30,800,000	4.87	32.14	62.98
	2	28,800,000	20.48	13.19	66.31
	3	114,000,000	20.17	11.40	68.42
	4	108,000,000	17.59	20.37	62.03
	5	76,000,000	14.47	3.94	81.57
	6				
	7	436,000,000	13.76	33.71	52.52
325	0	43,400	23.04	32.02	44.93
	1	660,000	7.57	42.42	50.00
	2	1,590,000	27.04	9.43	63.52
	3	5,500,000	49.09	5.45	45.45
	4	24,000,000	15.41	5.41	79.16
	5				
	6	475,000,000	14.10	42.10	43.78
326	0	30,700	6.84	26.38	66.77
	1	400,000	27.50	12.50	60.00
	2	840,000	36.90	4.76	58.33
	3	910,000	38.46	3.29	58.24
	4				
	5	241,000,000	21.99	6.63	71.36
	6	563,000,000	5.68	69.98	24.33
327	0	149,000	22.81	29.53	47.65
	1	260,000	25.00	11.92	63.07
	2	19,000,000	20.00	1.57	78.42
	3				
	4	411,000,000	21.89	48.66	29.44
	5	1,220,000,000	4.91	59.83	35.24
328	0	126,000	26.98	43.65	29.36
	1	17,900,000	32.40	27.37	40.22
	2				
	3	508,000,000	27.55	51.57	20.86
329	0	14,200	23.23	26.03	50.70
	1				
	2	116,000,000	31.03	17.24	51.72
	3	240,000,000	3.75	80.00	16.25
	4	404,000,000	18.56	51.23	30.19
330	0	125,000	18.40	29.60	52.00
	1	9,500,000	29.47	15.78	54.73
	2	45,000,000	14.88	23.55	61.55
	3	213,000,000	23.47	22.06	54.46
	4	820,000,000	17.07	40.24	42.68
331	0	523,000	6.69	52.58	40.72
	1	8,900,000	31.46	16.85	51.68
	2	79,000,000	17.72	34.17	48.10
	3	84,000,000	15.47	45.23	39.28
	4	226,000,000	23.45	24.77	51.76
332	0	627,000	25.35	23.60	51.03
	1	21,000,000	10.95	43.33	45.71
	2	92,000,000	20.65	34.78	44.56
	3	184,000,000	16.84	40.76	42.39
333	0	172,000	8.72	33.72	57.55
	1	7,000,000	32.85	8.57	58.57
	2	53,000,000	24.52	16.98	58.49
	3				
	4	860,000,000	25.58	20.93	53.48
	5	690,000,000	14.49	33.33	52.17
334	0	464,000	96.98	.43	2.58
	1	1,100,000	40.90	4.54	54.54
	2				
	3	123,000,000	45.28	6.50	38.21
	4	167,000,000	45.50	8.38	46.10
335	0	324,000	14.19	12.34	73.45
	1				
	2	123,000,000	17.88	20.32	61.78
	3	194,000,000	15.46	38.14	46.39
	4	150,000,000	17.33	41.33	41.33
336	0	243,000	16.46	30.86	52.67
	1	3,810,000	17.58	30.70	51.70
	2	47,900,000	11.48	16.07	72.44
	3	190,000,000	15.78	42.10	42.10
	4	182,000,000	18.13	23.62	58.24
337	0	146,000	17.12	18.49	64.38
	1	7,030,000	17.49	.56	81.93
	2	120,000,000	33.33	16.66	50.00
	3	167,000,000	15.56	27.54	56.88
338	0	36,000	14.44	26.11	59.44
	1	3,700,000	27.02	10.81	62.16
	2	37,000,000	40.54	16.21	43.24
	3				
	4	306,000,000	10.13	52.61	37.25
339	0	78,000	23.07	34.61	42.30
	1	3,210,000	18.69	28.66	52.64
	2				
	3	143,000,000	6.29	34.26	59.44
	4	564,000,000	7.09	54.07	38.82
340	0	1,190,000	7.56	56.30	36.13
	1				
	2	152,000,000	7.23	38.81	53.94
	3	335,000,000	4.17	68.35	27.46

Table XVII.—*Raw milk at Washington, D. C.—Daily total counts and group percentages of bacteria—Milk held at 10° C. (50° F.)*—Continued.

CLEAN MILK—DAIRY S.

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
341	0	4,400	34.09	13.63	52.27
	1	50,000	30.00	....	70.00
	2	31,200,000	9.61	....	90.38
	3	34,000,000	20.58	....	79.41
	4	200,000,000	30.00	....	70.00
	5	140,000,000	31.42	5.71	62.85
	6	....	....	....	....
	7	410,000,000	36.58	17.07	46.34
342	0	1,400	57.14	14.28	28.57
	1	4,000	52.50	22.50	25.00
	2	868,000	4.14	....	95.85
	3	36,700,000	8.71	....	91.28
	4	81,000,000	6.17	....	93.82
	5	....	....	....	....
	6	590,000,000	3.38	42.37	54.23
343	0	67,000	43.28	5.97	50.74
	1	8,200,000	20.73	....	79.26
	2	27,700,000	18.05	.72	81.22
	3	....	....	....	....
	4	292,000,000	4.79	38.01	57.19
344	0	5,400	70.37	11.11	18.51
	1	170,000	35.29	....	64.70
	2	....	....	....	....
	3	122,000,000	11.47	.81	87.70

Table XVIII.—*Raw milk at Washington, D. C.—Daily total counts and group percentages of bacteria—Milk held at room temperature, 20° C. (68° F.).*

Sample No.	Age of milk in days.	Total bacteria per c. c. on litmus lactose gelatin.	Percentage of peptonizing bacteria.	Percentage of lactic-acid bacteria.	Percentage of alkali or inert bacteria.
345	0	39,000	12.82	25.64	61.53
	1	140,000,000	42.85	14.28	42.85
	2	500,000,000	2.40	85.00	12.60
346	0	246,000	10.16	40.65	49.18
	1	121,000,000	6.61	57.85	35.53
	2	654,000,000	8.25	65.59	26.14
347	0	102,000	14.70	16.66	68.62
	1	69,000,000	15.94	8.40	75.65
348	0	40,800	20.58	39.46	39.95
	1	73,000,000	5.47	69.86	24.65
	2	72,000,000	9.72	43.05	47.22
349	0	78,000	15.38	24.35	60.25
350	0	34,600	15.38	41.04	43.06
	1	73,000,000	26.02	31.50	42.46
	2	86,000,000	9.30	56.97	33.72
351	0	372,000	5.64	71.77	22.58
	1	168,000,000	13.09	59.52	27.38
	2	1,070,000,000	5.60	74.76	19.62
352	0	25,000	44.00	32.00	24.00
	1	64,000,000	59.37	7.81	32.82
	2	416,000,000	17.06	29.08	53.84
353	0	19,700	15.22	20.81	63.95
	1	70,000,000	14.28	25.71	60.00
	2	349,000,000	14.04	37.24	48.71
354	0	257,000	5.44	63.81	30.73
	1	94,000,000	19.14	10.63	70.22
355	0	111,000	32.43	22.52	45.04
	1	....	....	....	....
	2	700,000,000	11.42	27.14	61.42
356	0	6,700	7.46	38.80	53.73
	1	14,500,000	41.37	11.03	47.58
	2	231,000,000	16.01	40.25	43.72
357	0	20,800	6.25	25.48	68.26
	1	29,200,000	28.76	31.16	40.06
	2	271,000,000	9.22	46.49	44.28
358	0	18,400	8.15	28.80	63.04
	1	12,000,000	11.66	37.50	50.83
	2	790,000,000	10.12	55.69	34.17
359	0	4,600	....	54.34	45.65
	1	88,000,000	32.95	12.50	54.54
	2	1,220,000,000	12.29	42.62	45.08
360	0	22,800	17.54	35.52	46.92
	1	83,000,000	37.34	20.48	42.16
	2	1,110,000,000	5.40	70.27	34.32
361	0	24,900	16.06	22.89	61.04
	1	123,000,000	19.51	25.19	55.28
	2	1,010,000,000	5.94	74.25	19.80
362	0	130,000	1.53	34.61	63.84
	1	111,000,000	13.51	36.93	49.54
	2	740,000,000	4.05	89.18	6.75
363	0	281,000	15.30	33.09	51.60
	1	234,000,000	23.07	11.96	64.95
	2	139,000,000	21.58	34.53	43.88

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